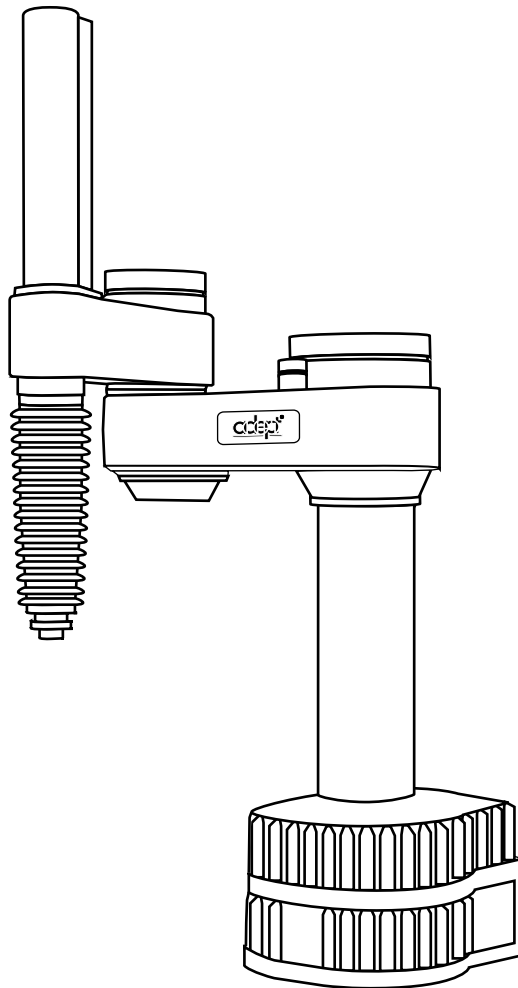


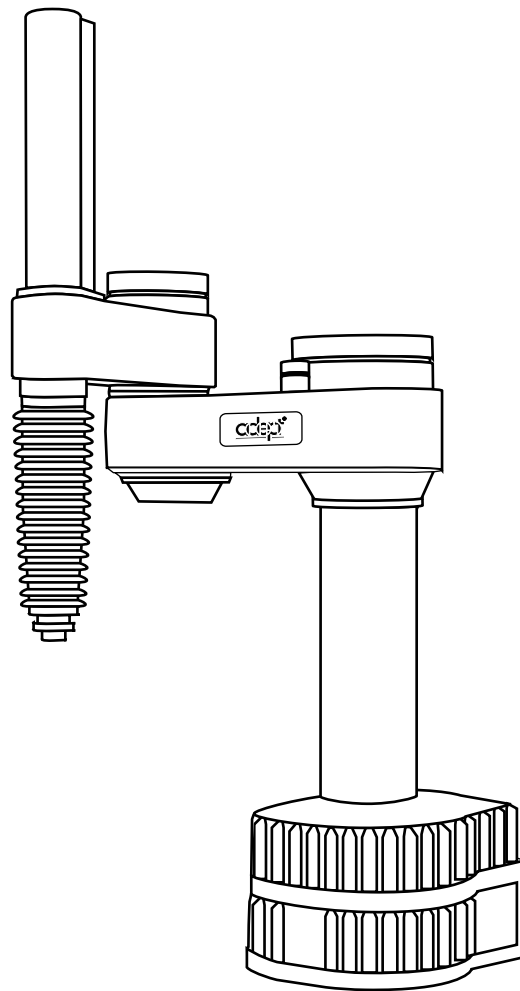
# Instruction Handbook

# AdeptOne-XL/ AdeptThree-XL Robot





# Instruction Handbook AdeptOne-XL/ AdeptThree-XL Robot



00862-00100, Rev. C  
January 1999



150 Rose Orchard Way • San Jose, CA 95134 • USA • Phone (408) 432-0888 • Fax (408) 432-8707

Otto-Hahn-Strasse 23 • 44227 Dortmund • Germany • Phone (49) 231.75.89.40 • Fax (49) 231.75.89.450

41, rue du Saule Trapu • 91300 • Massy • France • Phone (33) 1.69.19.16.16 • Fax (33) 1.69.32.04.62

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# Manufacturer's Declaration

We/Wir/Nous, **Adept Technology, Inc., 150 Rose Orchard Way, San Jose, California 95134, USA**, in accordance with EU Directive 89/392/EEC, Annex II.B, declare under our sole responsibility that the product / erklären in alleiniger Verantwortung, daß das Produkt / déclarons sous notre seule responsabilité que le produit:

| EN 954:                                                                       |               | Category/Klasse/Catégorie 1 | Category/Klasse/Catégorie 3 |
|-------------------------------------------------------------------------------|---------------|-----------------------------|-----------------------------|
| Robot/Roboter:                                                                | AdeptThree-XL | 30862-10300                 | 30862-10300                 |
|                                                                               | AdeptOne-XL   | 30862-10301, -10304         | 30862-10301, -10304         |
| Pendant/Handbediengerät/<br>Unità portatile:                                  | MCP III       | 90332-48050                 | 90332-48050                 |
| Control system /<br>Steuerung/<br>Système de commande/<br>Sistema di comando: | Adept MV-10   | 30340-20000, -40000         | 30340-20000, -40000         |
|                                                                               | Adept PA-4    | 30336-31000                 | 30336-31000                 |
|                                                                               | A Amp         | 10337-15200                 | 10337-15200                 |
|                                                                               | Dual B+ Amp   | 10338-51000                 | 90338-51010                 |
|                                                                               | CIP           | 30350-10350                 | 30350-10350                 |
|                                                                               | MMSP          | —                           | 90862-00700                 |

to which this declaration relates is in conformity with the following standards. / auf das sich diese Erklärung bezieht, mit den folgenden Normen. / auquel se réfère cette déclaration est conforme aux normes.

We declare that the machine in the form delivered by us, subject to the usage conditions specified below, complies with the relevant and fundamental safety and health requirements defined in EU Directive 89/392/EEC, Annex I, and the following standards. The machine must not be put into operation until all of the machinery into which it is incorporated has been declared in compliance with the provisions of the effective versions of the directives. This includes all supplementary equipment and protective devices.

| EU/EEA:                             |                                           | IEC/ISO:        |
|-------------------------------------|-------------------------------------------|-----------------|
| EN 55011:1991, Class A              | (EMC: Emissions)                          | CISPR 11: 1990  |
| EN 50082-2: 1995                    | (EMC: Immunity)                           | —               |
| EN 292-1: 1991 & EN292-2 + A1: 1995 | (Safety of machinery)                     | —               |
| EN 60204-1: 1997, IP20              | (Electrical safety)                       | IEC 204-1: 1992 |
| EN 775: 1992                        | (Robot safety)                            | ISO 10218:1992  |
| EN 954-1:1996                       | (Safety related parts of control systems) | —               |
| EN 1050: 1996                       | (Risk assessment)                         | —               |

## EU Directives / EG-Richtlinien / Directives Communautaire / Direttiva CE:

89/392, 91/368, 93/44, 93/68 (Machinery)

89/336, 92/31, 93/68 (EMC)

73/23, 93/68 (Electrical Equipment)

## Usage and installation conditions

The product must be installed and used strictly in accordance with the *AdeptOne/AdeptThree-XL Robot Instruction Handbook* (document p/n 00862-00100). In particular, the robot system must be installed with user-supplied perimeter barrier interlocks. The design of the barrier interlocks must provide a Category 3 level of control per EN 954.

*If the system has the EN 954 Category 1 Control System option:* The barrier interlocks must interrupt the AC supply to the PA-4 Power Chassis in the event of personnel attempting to enter the workcell. You must teach the robot from outside the barrier, or with arm power off.

The system must incorporate only those plug-in modules and accessories listed in Table 1 or Table 2. If modules or accessories listed in Table 2 are installed, the user must verify conformance to the EMC Directive after installation.

This Declaration applies only to those Adept product part numbers specifically listed in this declaration. The following changes may result in the system not complying with the applicable Directives, and would void this declaration unless additional testing and/or evaluation is performed by the user:

- unauthorized user modifications;
- substitution or addition of Adept parts not listed on this declaration;
- addition of user-supplied parts and accessories.



Richard J. Casler, Jr. (Vice President, Engineering)

23 November 1998

San Jose, California, USA

DEUTSCH: Hiermit erklären wir, daß die nachstehende Maschine in der von uns gelieferten Ausführung, den einschlägigen, grundlegenden Sicherheits- und Gesundheitsanforderungen der EG-Richtlinie 89/392/EWG Anhang I, und den unten aufgeführten Standarts entspricht. Dies gilt nur wenn das Geraet unter den unten genannten Bedingungen verwendet wird. Wir weisen daraufhin, daß die Inbetriebnahme der Maschine solange untersagt ist, bis festgestellt ist, daß die Maschine, in die diese Maschine eingebaut werden soll, den Bestimmungen der Richtlinie in der jeweils gueltigen Fassung entspricht. Dies schließt die anwenderseitig in die Maschine zu installierenden Ergänzungen und Schutzeinrichtungen ein.

FRANÇAIS: Par la présente, nous déclarons que la machine décrite ci-dessous, livrée en l'état, est conforme à la directive communautaire 89/392/CEE, Annexe I, sur les impératifs fondamentaux en matière de santé et de sécurité. La machine ne pourra être mise en service avant que la machine dans laquelle elle sera incorporée ne soit déclarée complètement conforme aux dispositions des directives en cours de validité. Ceci comprend tout équipement complémentaire et dispositif de protection.

ITALIANO: Si dichiara che la macchina, come da noi fornita, soddisfa i requisiti fondamentali definiti nella direttiva CE 89/392/EEC, Appendice I, in fatto di sicurezza e sanità. La messa in funzione della macchina resta vietata fintanto che l'intero sistema nel quale questa è incorporata sia stato dichiarato conforme alla versione vigente della suddetta normativa. Il sistemasi intende comprensivo di tutte le parti accessorie e dispositivi di sicurezza.

## Conditions d'utilisation et d'installations

L'équipement doit être installé et utilisé en respectant scrupuleusement les instructions du manuel «Manuel d'utilisation du robot AdeptOne/AdeptThree-XL». En particulier, les barrières de sécurité doivent être conçues et installées pour fournir un niveau de sécurité de catégorie 3 conforme à la norme EN 954.

*Si la système fournis par Adept confèrent, selon la norme EN954, un niveau de sécurité de catégorie 1: L'ensemble robotisé doit comporter une enceinte de sécurité, non fournie par Adept, sectionnant l'alimentation 380V du châssis d'alimentation des variateurs (PA-4) lors de l'intrusion d'une personne alors que le robot est asservi. L'apprentissage des positions doit se faire de l'extérieur de cette enceinte de sécurité ou lorsque le robot est hors asservissement.*

L'ensemble ne doit comporter que les cartes enfichables ou accessoires listés dans les tableaux 1 ou 2. Si des accessoires listés dans le tableau 2 sont installés, l'utilisateur devra, après installation, vérifier la conformité avec les directives EMC.

Cette déclaration ne s'applique que sur les produits Adept dont les numéros de référence sont spécifiquement listés dans cette déclaration. Les modifications suivantes sont susceptibles d'annuler la conformité des équipements avec les directives de sécurité a moins que de nouveaux tests ne soient effectués

- Modifications non autorisées des équipements,
- Substitution ou ajout de composants non listés dans cette déclaration,
- Ajout de composants ou accessoires par le client.

## Plug-in Modules and Accessories / Einschubmodule und Zubehör / Modules enfichables et accessoires

**Table 1: Table/Tabelle/Tableau 1**

| <b>Table/Tabelle/Tableau 1</b>                                                          |                         |                                          |                     |
|-----------------------------------------------------------------------------------------|-------------------------|------------------------------------------|---------------------|
| Description / Beschreibung                                                              | Name / Namen /<br>/ Nom | Part Number / Teilenummer /<br>Référence | Revision / Révision |
| VME Digital I/O Board /<br>Digitales Ein-/Ausgabemodul /<br>Carte d'entrées/sorties VME | DIO                     | 10332-00800                              | >= P2               |
| VME Graphics Board / Graphik<br>Modul / Carte graphique VME                             | VGB                     | 10332-10250                              | >= P3               |
| VME Joint Interface Board /<br>Achssteuerkarte / Carte d'axe                            | EJI                     | 10332-00505                              | >= A                |
| VME Motion Interface Board /<br>Achssteuerkarte / Carte<br>d'interface Mouvement VME    | MI3                     | 10332-11400                              | >= P4               |
|                                                                                         | MI6                     | 10332-12400                              | >= P2               |
| AWC Processor Board /<br>AWC Prozessormodul /<br>Carte processeur AWC                   | AWC 040                 | 10332-00714                              | >= P1               |
|                                                                                         | AWC 060                 | 10332-00716                              | >= P1               |
| VME Vision Board / Vision modul /<br>Module d'interface vision VME                      | VIS                     | 10332-00600                              | >= P2               |
|                                                                                         | EVI                     | 10332-00655                              | >= P1               |
| Camera / Kamera / Caméra                                                                | —                       | 15600-00090                              | >= A                |
| Optional AUX SIO Board /                                                                | SIO                     | 30332-12350                              | >= P2               |
| AUX SIO Modul /                                                                         | SIO                     | 30332-12351                              | >= P2               |
| Module AUX SIO                                                                          | SIO/IDE                 | 30332-22350                              | >= A                |
|                                                                                         | SIO/IDE                 | 30332-22351                              | >= A                |

**Table 2: Table/Tabelle/Tableau 2**

| <b>Table/Tabelle/Tableau 2</b>                                                                  |                         |                                          |                     |
|-------------------------------------------------------------------------------------------------|-------------------------|------------------------------------------|---------------------|
| Description / Beschreibung                                                                      | Name / Namen /<br>/ Nom | Part Number / Teilenummer<br>/ Référence | Revision / Révision |
| Ethernet kit / Ethernet Ausrüstung /<br>Ethernet kit                                            | AdeptNet                | 90332-02020                              | >= P1               |
| VME Analog I/O Module / Analog<br>Ein-Ausgabemodul / Carte<br>d'entrées-sorties analogiques VME | AIO                     | 10330-00970                              | >= B                |
| Force-sensing kit / VFI Ausrüstung<br>Capteur d'efforts                                         | VFI                     | 90211-00000, -08464, -00550              | >= B                |
| MP6 Kit / MP6 Ausrüstung /<br>Kit MP6                                                           | MP6                     | 90332-12400                              | >= A                |

**NOTE:** Products listed in Table 2 must be tested by the user in the final system configuration to assure full compliance with the European EMC Directive.

**NOTE:** Les produits listés dans le tableau 2 doivent être testés par l'utilisateur après l'assemblage et la configuration finale des équipements afin de s'assurer que l'ensemble réponde aux directives Européennes EMC.



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# Safety 1

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The Adept-XL robots are four-axis SCARA<sup>1</sup> robots (see Figure 1-1). Joints 1, 2, and 4 are rotational; joint 3 is translational. See Figure 1-2 for a description of the robot joint locations.

The Adept-XL robots require an Adept MV series controller and a PA-4 power chassis (see Figure 1-3 on page 26). The robot is programmed and controlled using the Adept MV controller and PA-4 amplifier control system. The optional Manual Mode Safety Package (MMSP) provides additional safety features (see Figure 5-1 on page 96). Specifications for the Adept-XL series of robots are provided in Chapter 11.

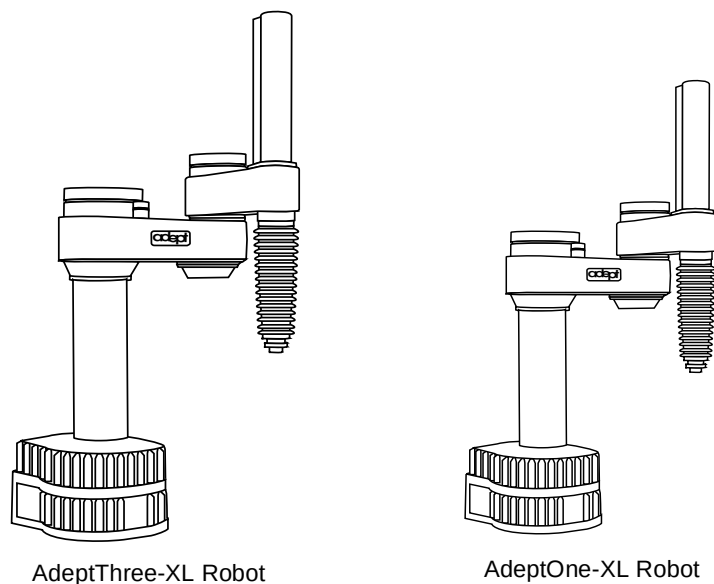


**Figure 1-1. Adept-XL Robots**

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<sup>1</sup> Selective Compliance Assembly Robot Arm

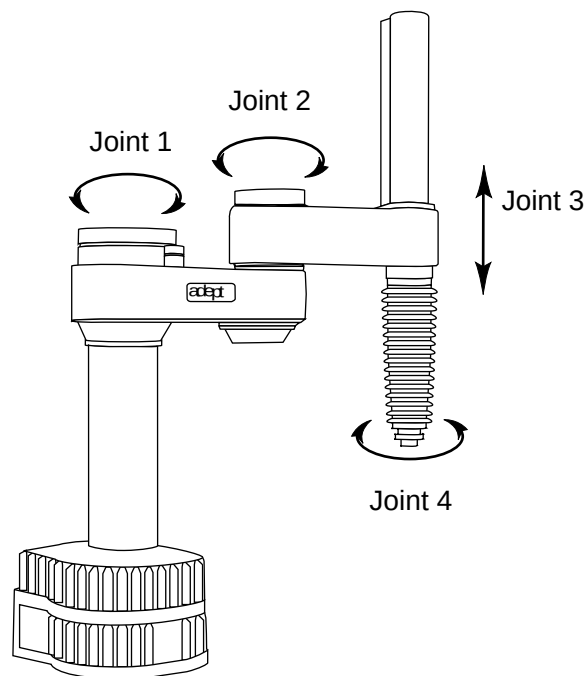


Figure 1-2. Adept-XL Robot Joint Motions

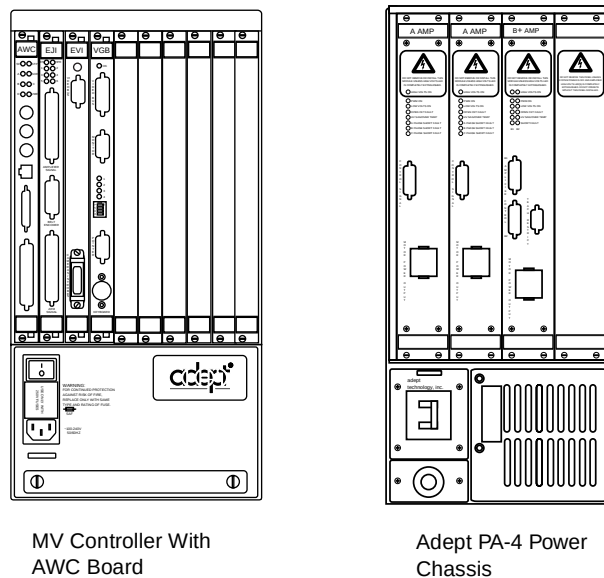


Figure 1-3. Adept MV-10 Controller and PA-4 Power Chassis

## Definition of a Manipulating Industrial Robot

An automatically controlled, reprogrammable, multipurpose, manipulative machine with several degrees of freedom, which may be either fixed in place or mobile for use in industrial automation applications is called a manipulating robot. (ISO 10218:1992(E))

## Adept Equipment Compatibility

This instruction handbook describes the installation and commissioning of Adept-XL robots (with and without the Manual Mode Safety Package). The optional Manual Mode Safety Package (MMSP) provides a Category 3 level of safety, as specified in EN 954, in section 1.3 on page 33.

The Adept robot system as described in this handbook must consist of the hardware and software listed in the following table. All new systems shipped from the factory will include the correct equipment as shown. If you have existing Adept equipment, this table can help distinguish new equipment from older equipment, especially since some of it is visibly similar. See the product data label for the robot, controller, and power chassis for model number or part number information.

For information on the V<sup>+</sup> operating system, refer to the *V<sup>+</sup> Operating System User's Guide*.

**Table 1-1. Adept Hardware and Software Compatibility for MMSP Systems**

| Product                                                                                 | Required Model, Part, or Version Number                                      |
|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| AdeptOne-XL robot<br>203 mm (8 in.) quill option<br>356 mm (14 in.) quill option        | Model Number 860<br>part number 30862-10301<br>part number 30862-10304       |
| AdeptThree-XL robot                                                                     | Model Number 862<br>part number 30862-10300                                  |
| Adept MV-10 controller                                                                  | part number 30340-40000                                                      |
| Adept MV-5 controller                                                                   | part number 30340-10000                                                      |
| Adept PA-4 power amplifier chassis                                                      | part number 30336-31000                                                      |
| A power amplifier                                                                       | part number 10337-15200                                                      |
| Dual B+ power amplifier                                                                 | part number 10338-51000                                                      |
| Manual Mode Safety Package (MMSP)<br>Option consisting of:<br>Category 3 Security Panel | part number 30335-00000                                                      |
| B+ power amplifier<br>with voltage restrict                                             | part number 90338-51010                                                      |
| Controller Interface Panel (CIP)                                                        | part number 30350-10350 (Category 1)<br>part number 30350-10350 (Category 3) |
| Manual Control Pendant III                                                              | part number 90332-48050 (MCP III)                                            |
| V <sup>+</sup> operating system software                                                | Version 13.0 or later                                                        |

## 1.1 Notes, Cautions, and Warnings

There are four levels of special notation used in this instruction handbook. In descending order of importance, they are:



**WARNING:** If the actions indicated in a “WARNING” are not complied with, injury or major equipment damage could result. A Warning statement will typically describe the potential hazard, its possible effect, and the measures that must be taken to reduce the hazard.



**WARNING:** If the WARNING is indicated with a lightning bolt instead of an exclamation mark, an electrical danger or shock is possible for personnel working with the system.



**CAUTION:** If the action specified in the “CAUTION” is not complied with, damage to your equipment could result.

**NOTE:** A “NOTE” provides supplementary information, emphasizes a point or procedure, or gives a tip for easier operation.

## 1.2 Precautions and Required Safeguards

This manual must be read by all personnel who install, operate, or maintain Adept systems, or who work within or near the workcell.



**WARNING:** Adept Technology strictly prohibits installation, commissioning, or operation of an installation with an Adept robot without adequate safeguards according to applicable local and national standards. Installations in EU and EEA countries must comply with EN 775/ISO 10218, sections 5,6; EN 292-1; and EN 60204, section 13.

## Maximum Robot Forces and Torques

Adept robots are computer-controlled mechanisms capable of exerting considerable force. Like all robot and motion systems, and most industrial equipment, they must be treated with respect by the user and the operator. (See Table 1-2 and Table 1-3.)

**Table 1-2. Maximum Torques and Forces (AdeptOne-XL Robot)**

| Torque                                                                                                    | Force               |
|-----------------------------------------------------------------------------------------------------------|---------------------|
| Joint 1 maximum static torque                                                                             | 330 N•m (244 ft-lb) |
| Joint 2 maximum static torque                                                                             | 255 N•m (188 ft-lb) |
| Maximum static force applied by the robot in XY plane, measured at the tool flange (joint 2 fully tucked) | 1187 N (267 lb)     |

**Table 1-3. Maximum Torques and Forces (AdeptThree-XL Robot)**

| Torque                                                                                                    | Force               |
|-----------------------------------------------------------------------------------------------------------|---------------------|
| Joint 1 maximum static torque                                                                             | 330 N•m (244 ft-lb) |
| Joint 2 maximum static torque                                                                             | 255 N•m (188 ft-lb) |
| Maximum static force applied by the robot in XY plane, measured at the tool flange (joint 2 fully tucked) | 1179 N (265 lb)     |

## Safety Barriers

Safety barriers must be an integral part of robot workcell design. Adept systems are computer-controlled, and may activate remote devices under program control at times or along paths not anticipated by personnel. It is critical that safeguards be in place to prevent personnel from entering the workcell whenever equipment power is present.

The robot system integrator, or end user, must ensure that adequate safeguards, safety barriers, light curtains, safety gates, safety floor mats, etc., will be installed. The robot workcell must be designed according to the applicable local and national standards (see section 1.8 on page 38).

The safe distance to the robot depends on the height of the safety fence. The height and the distance of the safety fence from the robot must ensure that personnel cannot reach the danger zone of the robot (see section 1.8 on page 38).

The Adept control system has features that aid the user in constructing system safeguards, including customer emergency stop circuitry and digital input and output lines. The emergency power-off circuitry is capable of switching external power systems, and can be interfaced to the appropriate user-supplied safeguards. See Chapter 5 for information on safe and effective use of the robot.

## Impact and Trapping Points

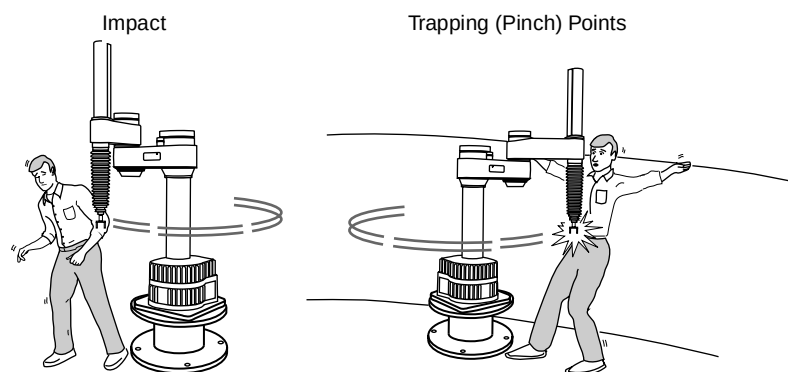


**Figure 1-4. Adept-XL Robot Impact and Trapping Point Hazards**

Adept robots are capable of moving at high speeds. If a person is struck by a robot (impacted) or trapped (pinched), death or serious injury could occur. Robot configuration, joint speed, joint orientation, and attached payload all contribute to the total amount of energy available to cause injury.

### Hazards From Expelling a Part or Attached Tooling

The maximum joint tip speeds that can be achieved by the Adept-XL robot in a **runaway** situation are listed in Table 1-4. Any tooling, fixtures, end-effectors, etc., mounted to the user flange, outer link, or inner link of the robot must be attached by sufficient means to resist being expelled from the robot. Additionally, any payload must be held by the end-effector in a manner that prevents the payload from being expelled accidentally.

**Table 1-4. Maximum Adept-XL Robot Joint Velocities in Runaway Situations<sup>a</sup>**

| Joint Max Angular/Linear Velocity | AdeptOne-XL         | AdeptThree-XL       |
|-----------------------------------|---------------------|---------------------|
| Joint 1 maximum angular velocity  | 1118 degrees/second | 920 degrees/second  |
| Joint 1 maximum linear velocity   | 10.4 meters/second  | 10.7 meters/second  |
| Joint 2 maximum angular velocity  | 1869 degrees/second | 1670 degrees/second |
| Joint 2 maximum linear velocity   | 31.8 meters/second  | 35.3 meters/second  |

<sup>a</sup> These velocities can occur only in a runaway or mechanical failure situation. These are *not* performance specifications (see Chapter 11 for robot performance specifications).

The safety fence or barrier constructed around the robot must be designed to withstand the impact of any item expelled accidentally from the robot. Projectile energy can be calculated using the formula  $E = 1/2mv^2$ . Here are two examples.

**Example 1:** 4 kg payload mounted to end-effector, joint 2 at 0° and all other joints stationary.

maximum possible projectile energy =  $1/2 (4 \text{ kg}) (17.1 \text{ m/s})^2 = 584 \text{ J}$  (431 ft-lb)

**Example 2:** 6 kg payload mounted to elbow (Joint 2).

maximum possible projectile energy =  $1/2 (6 \text{ kg}) (10.7 \text{ m/s})^2 = 343 \text{ J}$  (253 ft-lb)

### Additional Safety Information

The standards and regulations listed in this handbook contain additional guidelines for robot system installation, safeguarding, maintenance, testing, start-up, and operator training. The table below lists some sources for the various standards.

**Table 1-5. Sources for International Standards and Directives**

|                                                                                                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BSI, British Standards Institute<br>Sales Department<br>Linford Wood<br>Milton Keynes<br>MK14 6LE United Kingdom<br>Phone 0181 996 7000<br>Fax 0181 996 7001<br><a href="http://www.bsi.org.uk">http://www.bsi.org.uk</a> |
| Beuth Verlag GmbH<br>10722 Berlin<br>Germany<br>Phone 030 26 01 - 22 60<br>Fax 030 26 01 - 12 60<br><a href="http://www.din.de/en/beuth/Beuth.html">http://www.din.de/en/beuth/Beuth.html</a>                             |
| IEC, International Electrotechnical Commission<br>Rue de Varembe 3<br>PO Box 131<br>CH-1211 Geneva 20, Switzerland<br>Phone 41 22 919-0211<br>Fax 41 22 919-0300<br><a href="http://www.iec.ch">http://www.iec.ch</a>     |
| American National Standards Institute (ANSI)<br>11 West 42nd Street, 13th Floor<br>New York, NY 10036, USA<br>Phone 212-642-4900<br>Fax 212-398-0023<br><a href="http://www.ansi.org">http://www.ansi.org</a>             |
| Document Center, Inc.<br>1504 Industrial Way, Unit 9<br>Belmont, CA 94002, USA<br>Phone 415-591-7600<br>Fax 415-591-7617<br><a href="http://www.doccenter.com">http://www.doccenter.com</a>                               |

**Table 1-5. Sources for International Standards and Directives (Continued)**

|                                                                                                                                                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Global Engineering Documents<br>15 Inverness Way East<br>Englewood, CO 80112, USA<br>Phone 800-854-7179<br>Fax 303-397-2740<br><a href="http://global.ihs.com">http://global.ihs.com</a>                      |
| Robotic Industries Association (RIA)<br>900 Victors Way<br>PO Box 3724<br>Ann Arbor, MI 48106, USA<br>Phone 313-994-6088<br>Fax 313-994-3338<br><a href="http://www.robotics.org">http://www.robotics.org</a> |

**Table 1-6. Other Standards Related Organizations**

|                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| American Electronics Association (AEA) Europe<br>40 rue des Drapiers<br>1050 Brussels, Belgium<br>Phone 011-32-502-7015<br>Fax 011-32-2-502-6734<br><a href="http://web1.aeanet.org/homepage/europe/council.html">http://web1.aeanet.org/homepage/europe/council.html</a><br><a href="http://www.aeanet.org">http://www.aeanet.org</a> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## 1.3 Risk Assessment

Without special safeguards connected to its control system, the Adept-XL robot could inflict serious injury to an operator working within its work envelope. Safety standards in several countries require that appropriate safety equipment be installed as part of the system. Table 1-7 lists some of the safety standards that affect industrial robots. This is *not* a complete list. You must comply with *all* applicable local and national standards for where the robot is installed.

**Table 1-7. Partial List of Worldwide Robot and Machinery Safety Standards**

| International | USA             | Canada          | Europe   | Title of Standard                                                       |
|---------------|-----------------|-----------------|----------|-------------------------------------------------------------------------|
| ISO 10218     |                 |                 | EN 775   | Manipulating Industrial Robots - Safety                                 |
|               | ANSI/RIA R15.06 | CAN/CSA-Z434-94 |          | Industrial Robots and Robot Systems - Safety Requirements               |
|               |                 |                 | EN 292   | Safety of Machinery - Basic Concepts, General Principles for Design     |
|               |                 |                 | EN 954-1 | Safety Related Parts of Control Systems - General Principles for Design |
|               |                 |                 | EN 1050  | Safety of Machinery - Risk Assessment                                   |

Applicable US standards include ANSI/RIA R15.06. Applicable European standards include EN 775, EN 954, and EN 1050. Applicable international standards include ISO 10218.

Adept has performed a risk assessment for this product, based on the intended applications of the robot. For *normal* operation, AUTO mode, user-supplied interlocked guarding must be installed to prevent anybody entering the workcell while High Power is on.

The risk assessment for *teaching* this product depends on the application. In many applications, the programmer will need to enter the robot workcell while High Power is enabled to teach robot locations. Other applications can be designed so that the programmer does not have to enter the work envelope while High Power is on. Examples of alternative methods of programming include:

1. Programming from outside the safety barrier.
2. Programming with High Power off (using brake release button).
3. Copying program from another (master) robot.
4. Off-line or CAD programming.

## 1.4 Risk Assessment – Category 1

### Installations Not Requiring Programmer to Enter Workcell



**WARNING:** The Adept-supplied system components provide a Category 1 control system as defined by EN 954. The robot system must be installed with user-supplied interlock barriers. The interlocked barrier should interrupt the AC supply to the PA-4 power chassis in the event of personnel attempting to enter the workcell when High Power is enabled, even for teaching in Manual mode. The user-designed interlocks themselves should be designed to provide a Category 3 level of control per EN 954. Failure to install suitable guarding could result in death or injury.



**WARNING:** If the programmer needs to enter the workcell when High Power is ON, Adept's risk assessment indicates that a Category 3 control system is required.

Some teaching methods do not require the programmer to enter the workcell. If these methods are used exclusively, the robot should be installed with interlocked guarding to ensure AC power is removed from the PA-4 power chassis whenever a person enters the workcell.

In situations with low exposure consideration factors, EN 1050 specifies use of a Category 1 Control System per EN 954. EN 954 defines a Category 1 Control System as one that employs Category B components designed to withstand environmental influences, such as voltage, current, temperature, and EMI and that employs well-tried safety principles. The standard Adept-XL control system (system without MMSP Control System) described in this handbook employs hardware components in its safety system that meet or exceed the requirements of the *EU Machinery Directive* and *Low Voltage Directives*.

Furthermore, the standard control system is fully hardened to all EMI influences per the *EU EMC Directive* and meets all functional requirements of ISO 10218 (EN 775) *Manipulating Robots Safely*. In addition, a software-based reduced speed and “soft-servo” mode has been incorporated to limit speed and impact forces on the Operator and production tooling when the robot is operated in Manual Mode.

In consideration of the above, the standard AdeptOne-XL / AdeptThree-XL control system meets or exceeds the requirements imposed by the EN 954 specified Category 1 level of safety, as evidenced by the Manufacturer's Declaration of Conformity at the front of this handbook.

Adept has performed a risk assessment based on intended applications of this product. Our assessment indicates that a Category 3 safety system, as defined in EN 954, is required to protect the operator and programmer. This protection may take two forms:

1. If a programmer may need to enter the cell with High Power on, then Adept's optional MMSP should be installed. The system must be installed so that no one can enter the workcell when the robot is in AUTO mode.

2. If no one will enter the workcell with High Power ON, not even to teach robot locations, then the user must provide a Category 3, dual-channel and cross checked, interlocked barrier system. The system must disconnect the AC power supply to the robot if any person enters the workcell.

## Installations Requiring Programmer to Enter Workcell

The Manual Mode Safety Package (MMSP) is available for the Adept XL family of robots. The MMSP protects a person teaching robot locations while inside the user-provided safety barrier, with High Power ON.

As a consequence of:

1. The potential for fatal injury,
2. The high probability that an operator could not avoid being hit by the robot in a high-acceleration, runaway, failure condition,

EN 1050 specifies use of a Category 3 Control System per EN 954. EN 954 defines a Category 3 Control System as one in which:

1. No single failure can cause a loss of the safety function.
2. Any failure that does occur can be “checked” prior to enabling power.

The optional Manual Mode Safety Package (MMSP) described in this handbook employs a fully redundant Emergency Stop that incorporates “Teach Restrict” sensors and self-checking hardware. Through use of a thorough Failure Mode and Effect Analysis, it has been determined that the MMSP, when installed and operated as described in this handbook, meets the stringent requirements of the Category 3 level of safety specified in EN 954. The MMSP has also been designed to meet relevant standards referenced in EN 954, including ISO 10218 (EN 775) *Manipulating Robots Safely*. Also see the Manufacturer’s Declaration on page 5.

Adept has performed a risk assessment based on intended applications of this product. Our assessment indicates that a Category 3 safety system, as defined in EN 954, is required to protect the operator and programmer. This protection may take two forms:

1. If a programmer may need to enter the cell with High Power on, then Adept’s optional MMSP should be installed. The system must be installed so that no one can enter the workcell when the robot is in AUTO mode
2. If no one will enter the workcell with High Power ON, not even to teach robot locations, then the user must provide a Category 3, dual-channel and cross checked, interlocked barrier system. The system must disconnect the AC power supply to the robot if any person enters the workcell.

## 1.5 Intended Use of the Robots

The installation and use of Adept products must comply with all safety instructions and warnings in this manual. Installation and use must also comply with all applicable local and national requirements and safety standards (see section 1.8 on page 38).

The AdeptOne-XL robot is intended for use in small parts assembly and material handling for payloads typically less than 12 kg (26.5 lb). A HyperDrive option is available for this robot that delivers higher power to the joint 1 and 2 motors. This option is used for applications that require faster throughput.

The AdeptThree-XL robot is intended for use in parts assembly and material handling for payloads less than 25 kg (55 lb) and for those applications that require a longer reach than the AdeptOne-XL robot.



**WARNING:** For safety reasons, it is prohibited to make certain modifications to Adept robots (see section 1.6).

The Adept MV controller and the Adept PA-4 power chassis are component subassemblies of a complete industrial automation system. The controller and power chassis subassemblies must be installed inside a suitable enclosure. The controller and power chassis subassemblies must not come into contact with liquids. Additionally, a standard Adept-XL robot must not come into contact with liquids. (An Adept-XL robot equipped with the IP 54 option can withstand some moisture contact.)

The Adept equipment is not intended for use in any of the following situations:

- In hazardous (explosive) atmospheres
- In mobile, portable, marine, or aircraft systems
- In life-support systems
- In residential installations
- In situations where the Adept equipment will be subject to extremes of heat or humidity. See Table 2-2 on page 47 for allowable temperature and humidity ranges.



**WARNING:**

The instructions for operation, installation, and maintenance given in this Instruction Handbook must be strictly observed.

Non-intended use of an Adept-XL robot can:

- Cause injury to personnel
- Damage the robot or other equipment
- Reduce system reliability and performance

All persons that install, commission, operate, or maintain the robot must:

- Have the necessary qualifications
- Read and follow exactly the instructions in this Instruction Handbook

If there is any doubt concerning the application, ask Adept to determine if it is an intended use or not.

## 1.6 Robot Modifications

It is sometimes necessary to modify the robot in order to successfully integrate it into a workcell. Unfortunately, many seemingly simple modifications can either cause a robot failure, or reduce the robot's performance, reliability, or lifetime. The following information is provided as a guideline to modifications.

### Acceptable Modifications

In general, the following robot modifications will not cause problems, but may affect robot performance:

- Attaching tooling, utility boxes, solenoid packs, vacuum pumps, screwdrivers, cameras, lighting, etc., to the inner link, outer link, or column.
- Attaching hoses, pneumatic lines, or cables to the robot. These should be designed so they do not restrict joint motion or cause robot motion errors.
- See Figure 7-9 on page 151 and Figure 7-10 on page 152 for allowable mounting hole positions.

### Unacceptable Modifications

The modifications listed below may damage the robot, reduce system safety and reliability, or shorten the life of the robot.



**CAUTION:** Making any of the modifications outlined below will void the warranty of any components that Adept determines were damaged due to the modification. You must contact Adept Customer Service if you are considering any of the following modifications.

- Modifying any of the robot harnesses or robot-to-controller cables.
- Modifying any drive system components, except as noted in Chapter 7.
- Modifying, including drilling or cutting, any robot casting is prohibited with the exception of the access covers for joint 1 and joint 2 and the quill cover (see Figure 7-9 on page 151 and Figure 7-10 on page 152).
- Modifying any robot electrical component or printed-circuit board.
- Routing additional hoses, air lines, or wires through the robot.
- Modifications that compromise EMC performance, including shielding modifications to cables.

## 1.7 Transport

Always use adequate equipment to transport and lift Adept products. See Chapter 2 for more information on transporting, lifting, and installing.



**WARNING:** Do not remain under the robot while it is transported.

## 1.8 Safety Requirements for Additional Equipment

Additional equipment used with the Adept-XL robot (grippers, conveyor belts, etc.) must not reduce the workcell safeguards.

All emergency stop switches must always be accessible.

If the robot is to be used in an EU or EEA member country, all components in the robot workcell must comply with the safety requirements in the European Machine Directive 89/392/EEC (and subsequent amendments) and related harmonized European, international, and national standards. For robot systems, these include: EN 775/ISO 10218, sections 5,6; EN 292-1, 3.71; and EN 60204, section 13. For safety fences, see EN 294.

In other countries, Adept strongly recommends, in addition to complying with the applicable local and national regulations, that a similar level of safety be obtained.

In the USA, applicable standards include ANSI/RIA R15.06 and ANSI/UL 1740.

In Canada, applicable standards include CAN/CSA Z434.

## 1.9 Sound Emissions

The sound emission level of the Adept-XL robot depends on the speed and payload. The maximum value is 90dB. (This is at maximum AUTO-mode speed.)

## 1.10 Thermal Hazard



**WARNING:** Thermal Hazard!

You can burn yourself. Do not touch the robot base or outer link shortly after the robot has been running at high ambient temperatures (40-50°C) (104-122°F) or at fast cycle times (over 60 cycles per minute). The robot skin/surface temperature can exceed 70°C (158°F).

## 1.11 Working Areas

Adept robots have a Manual and an Automatic (AUTO) operating mode. While in Automatic Mode, personnel are not allowed in the workcell.

In Manual Mode, operators with additional safety equipment (see section 1.13 on page 40) are allowed to work in the robot workcell if the MMSP option incorporated. For safety reasons the operator should, whenever possible, stay outside of the robot work envelope to prevent injury. The maximum speed and power of the robot is reduced but it could still cause injury to the operator.

Before performing maintenance in the working envelope of the robot, High Power must be switched off and the power supply of the robot must be disconnected. After these precautions, a skilled person is allowed to maintain the robot. See section 1.12 on page 39 for the specifications.

The Adept-XL robot can work in Automatic Mode at high speeds and accelerations and can trap persons or crush them. The impact of a robot can kill a person.



**WARNING:**

Electrical Hazard!

Impact Hazard!

Never remove any safeguarding and never make changes in the system that will decommission a safeguard.

## 1.12 Qualification of Personnel

This manual assumes that all personnel have attended an Adept training course and have a working knowledge of the system. The user must provide the necessary additional training for all personnel who will be working with the system.

As noted in this handbook, certain procedures should be performed only by **skilled** or **instructed** persons. For a description of the level of qualification, Adept uses the standard terms:

- **Skilled persons** have technical knowledge or sufficient experience to enable them to avoid the dangers, electrical and/or mechanical.
- **Instructed persons** are adequately advised or supervised by skilled persons to enable them to avoid the dangers, electrical and/or mechanical.

All personnel must observe sound safety practices during the installation, operation, and testing of all electrically powered equipment. To avoid injury or damage to equipment, always remove power by disconnecting the AC power from the source before attempting any repair or upgrade activity. Use appropriate lockout procedures to reduce the risk of power being restored by another person while you are working on the system.



**WARNING:** The user must get confirmation from every entrusted person before they start working with the robot that the person:

1. Has received the instruction handbook
2. Has read the instruction handbook
3. Understands the instruction handbook and
4. Will work in the manner specified by the instruction handbook.

## 1.13 Safety Equipment for Operators

Adept advises operators to wear extra safety equipment in the workcell. For safety reasons operators must wear the following when they are in the robot workcell.

- Safety glasses
- Protective headgear (hard hats)
- Safety shoes

Install warning signs around the workcell to ensure that anyone working around the robot system knows they must wear safety equipment.

## 1.14 Protection Against Unauthorized Operation

The system must be protected against unauthorized use. Restrict access to the keyboard and the Manual Control Pendant by locking them in a cabinet or use another adequate method to prevent access to them.

## 1.15 Safety Aspects While Performing Maintenance

Only skilled persons with the necessary knowledge about the safety and operating equipment are allowed to maintain the robot, controller, and power chassis.



**WARNING:** During maintenance and repair, the power of the Adept PA-4 power chassis and the Adept MV controller must be turned off. Unauthorized third parties must be prevented from turning on power through the use of fail-safe lockout measures. (Turn off the circuit breakers, lock the cabinet, and remove the key!)

## 1.16 Risks That Cannot Be Avoided

### For Systems with MMSP Option

The Manual Mode Safety Package (MMSP) Category 3 Adept-XL robot control system implementation has a series of electromechanical devices that disable High Power if a system failure occurs.

The following situations may result in risks that cannot be avoided:

- Purposely defeating any aspect of the safety E-Stop system
- Improper installation or programming of the robot system
- Use of cables other than those supplied or use of modified components in the system
- Failure of a second device in a redundant safety circuit

Take precautions to ensure that these situations do not occur (see Chapter 10).

### For Systems Without MMSP Option

The following situations may result in risks that cannot be avoided:

- Purposely defeating any aspect of the safety E-Stop system
- Improper installation or programming of the robot system
- Unauthorized use of cables other than those supplied or use of modified components in the system
- Defeating interlock so that operator can enter workcell with High Power ON

Take precautions to ensure that these situations do not occur (see Chapter 10).

## 1.17 What to Do in an Emergency Situation

Press any E-Stop button (a red push-button on a yellow background/field) and then follow the internal procedures of your company or organization for an emergency situation. If a fire occurs, use CO<sub>2</sub> to extinguish the fire.



**WARNING:** Do not disconnect the compressed air supply to the robot unless you are sure that nobody is trapped near the robot. Disconnecting the air supply will prevent the brake release function from operating. This function may be required to release or gain access to a person trapped in the workcell.

## 1.18 How Can I Get Help?

Refer to the *How to Get Help Resource Guide* (Adept P/N 00961-00700) for details on getting assistance with your Adept software or hardware.

You can obtain this document through Adept On Demand. The phone numbers are:

(800) 474-8889 (toll free)  
(503) 207-4023 (toll call)

Please request document number 1020.

## 1.19 Related Manuals

This manual covers the installation and maintenance of an Adept-XL robot system. There are additional manuals that cover programming the system, reconfiguring installed components, and adding additional optional components. The following manuals (available on the documentation CD-ROM provided with each system) provide information on advanced configurations and system specifications.

**Table 1-8. Related Manuals**

| Manual Title                                                      | Description                                                                                                                                                |
|-------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Adept MV Controller User's Guide</i><br>00330-01040            | Describes the configuration and interface options for all Adept supplied processor boards and components that can be installed in an Adept control system. |
| <i>AdeptWindows User's Guide</i><br>00963-07300                   | Describes complex network installations, installation and use of NFS server software, the Adept Windows Offline Editor, and the AdeptWindows DDE software. |
| <i>Instructions for Adept Utility Programs</i><br>00963-00000     | Describes the utility programs used for advanced system configurations, system upgrades, file copying, and other system configuration procedures           |
| <i>V<sup>+</sup> Operating System User's Guide</i><br>00963-02300 | Describes the V <sup>+</sup> operating system including, disk file operations, monitor commands, and monitor command programs.                             |
| <i>V<sup>+</sup> Language User's Guide</i><br>00963-013000        | Describes the V <sup>+</sup> language and programming of an Adept control system.                                                                          |

# Installation Overview 2

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This chapter covers the facility electrical and mechanical specifications and other general installation requirements.

The next several chapters cover the installation of the robot, the robot control system, optional Adept-supplied equipment, and optional user-supplied equipment. In general, a complete installation will proceed as described in the following chapters:

- Chapter 3 covers installing the robot.
- Chapter 4 covers installation of the control system and power amplifiers.
- Chapter 5 covers installation and configuration of the optional Manual Mode Safety Package (MMSP). Complete the installation instructions in this chapter only if you have the MMSP option.
- Chapter 6 covers selection and installation of a user interface.
- Chapter 7 covers installation of optional equipment.

Once the physical installation is complete, the installation must be verified and the system must be commissioned.

- Chapter 8 covers verifying that the installation is correct and commissioning the system.

## 2.1 Hardware to Be Provided by User

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The user must supply the following minimum hardware. Your system may include additional user-supplied equipment as described in Chapter 7.

### All Systems

- Mounting plate or spool (see “Mounting Surface Specifications” on page 45)
- Installation tools (see “Tool and Equipment Requirements” on page 53)
- End-effector (see “Installing End-Effectors on an Adept-XL Robot” on page 153)
- Safety barrier (see “Safety Barriers” on page 29)
- Ground wire for robot (see “Adept Robot Grounding” on page 93)
- Ground wire for robot-mounted equipment (see “Robot-Mounted Equipment Grounding” on page 94)
- Optional AC 10A contactor

## Systems Without MMSP Option

- Optional 24VDC power supply (see “System Power Switch” on page 76)

## Systems With MMSP Option

- 5-wire power cord for security panel (see “Changing the Power Chassis Voltage Setting” on page 89)
- Ground wire for security panel (see “Grounding an MMSP Equipped System” on page 110)

## 2.2 Facility Requirements

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### Compressed Air Requirements

The Adept-XL robot requires clean, dry, oil-free, compressed air at 4.8 – 7.6 bar (70-110 psi) with a flow rate of 28 liters per minute (1 SCFM). This compressed air is used to release the robot brakes and optionally to provide air to the User air lines. End-effectors attached to the robot may require additional air flow. Insufficient air pressure or flow will cause the brakes to engage, which will disable High Power.



**CAUTION:** Failure to supply clean, dry, oil-free air may result in damage to mechanical, electrical, or pneumatic components inside the robot.

The user must supply all tubing and fittings to plumb the facility air supply to the robot. The robot is supplied with an air filter with a standard 1/4-inch Industrial Interchange nipple (1/4 NPT type thread). The compressed air to the robot must meet the specifications listed above. Also see Figure 7-7 on page 148.



**WARNING:** The compressed air supply must be fed from a source that normally remains ON during an emergency stop. Disconnecting the air supply will prevent the brake release from operating. In an emergency, the brake release may be required to release or gain access to a person trapped in the workcell. Any manually operated isolation valves that could be used to interrupt the compressed air supply to the robot should be clearly labeled to indicate that the supply should be left ON in an emergency.

**NOTE:** An air filter is supplied in the robot accessory kit and should be installed on the robot prior to connecting the compressed air supply.

## Mounting Surface Specifications

The floor at the installation site must be concrete with a minimum thickness of 100 mm (4-in.) and must comply with all national and local codes. The floor should be level. Due to the high torque (405 N•m [432 ft-lb] at the base) transmitted by the robot, it **must** be mounted to an extremely rigid structure. Any mounting structure vibration or flexing will seriously degrade robot performance. Adept recommends using either a mounting plate or a mounting spool. Both have proven reliable over extended periods of use. If another type of mounting structure is used, it must adequately resist vibration and flexure.

### Plate

Using a flat steel plate is mandatory if the robot is to be mounted directly to the facility floor. The mounting plate should conform to the following specifications:

**Table 2-1. Mounting Plate Specifications**

|                           |                                                                                                              |
|---------------------------|--------------------------------------------------------------------------------------------------------------|
| Material                  | carbon steel                                                                                                 |
| Diameter, minimum         | 610 mm (24.0 inches)                                                                                         |
| Thickness, minimum        | 25 mm (1.0 inch)                                                                                             |
| Mounting surface flatness | within 0.5 mm (0.02 inch)                                                                                    |
| Mounting hole pattern     | as shown in Figure 3-2                                                                                       |
| Mounting surface level    | must be level to within $\pm 0.3$ degrees ( $\pm 2.5$ mm [0.1 in.] for a 610 mm [24 in.] spool) <sup>a</sup> |

<sup>a</sup> For MMSP equipped systems, the mounting surface must be level to within  $\pm 0.25$  degrees.

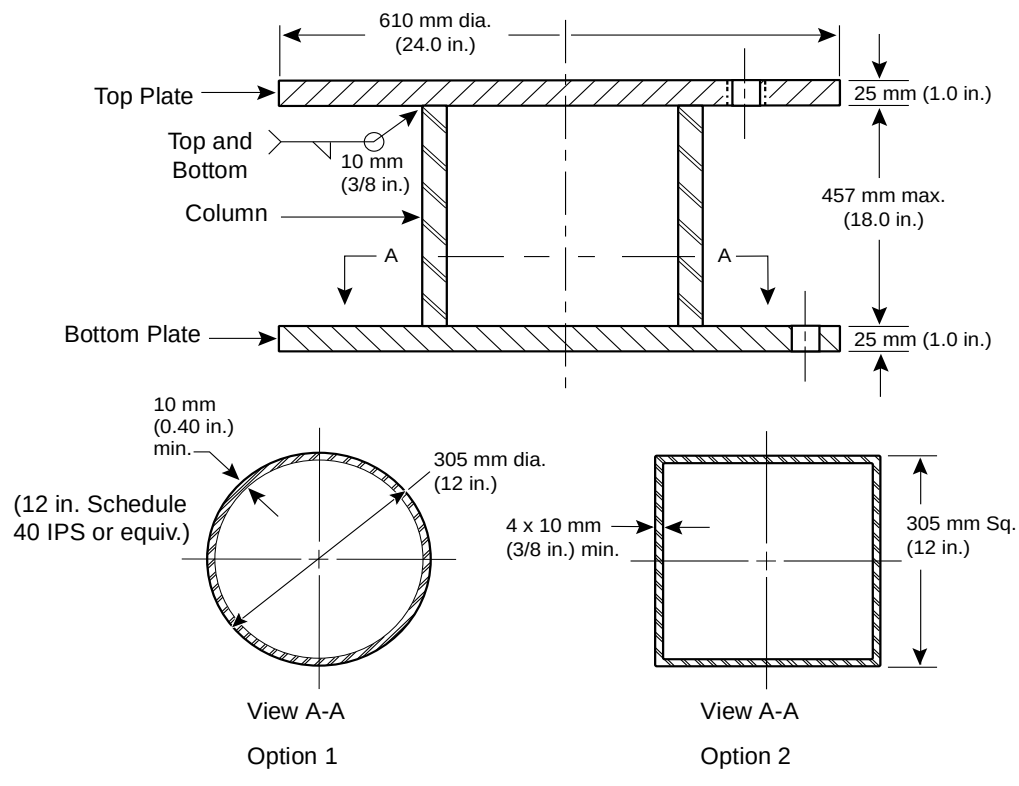


**WARNING:** The specification for leveling the mounting surface is critical on MMSP systems. The Teach Restrict sensor in the outer link will not function properly if the robot is not level.

### Spool

Another method of mounting uses a steel spool. See Figure 2-1 on page 46 for the specifications and dimensions of a robot spool. All of the specifications for the mounting plate in the previous section apply to the top plate of the mounting spool.

The recommended design for a manufactured spool is a welded assembly consisting of three steel parts, top and bottom plates welded to a center column as detailed in Figure 2-1.



Material: Carbon Steel      Material Surface Flatness: 0.5 mm (0.02 in.)

Mounting Surface Level: within  $\pm 0.25$  degrees ( $\pm 2.5$ mm [0.1 in.] over 610 mm [24 in.]

**Figure 2-1. Mounting Spool Specifications**

See Figure 3-2 on page 55 for the robot mounting hole pattern.

## 2.3 Environmental Requirements

The Adept robot system installation must meet the operating environment requirements shown in Table 2-2. See Table 2-3 on page 48 for the Adept MV controller electrical requirements and Table 2-4 on page 49 for the PA-4 amplifier chassis electrical requirements.

**Table 2-2. Robot System Operating Environment Requirements**

|                                                                                                                                              |                                                                                                                                                                                  |
|----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ambient temperature                                                                                                                          |                                                                                                                                                                                  |
| Adept-XL robot                                                                                                                               | 5°C to 50°C (41°F to 122°F)                                                                                                                                                      |
| controller – while accessing floppy or hard drive                                                                                            | 5°C to 40°C (41°F to 104°F)                                                                                                                                                      |
| controller – while not accessing floppy or hard drive                                                                                        | 5°C to 50°C (41°F to 122°F)                                                                                                                                                      |
| power chassis                                                                                                                                | 5°C to 40°C (41°F to 104°F)                                                                                                                                                      |
| Humidity                                                                                                                                     | 5 to 90%, non-condensing                                                                                                                                                         |
| Altitude                                                                                                                                     | up to 2000 m (6500 ft.)                                                                                                                                                          |
| Pollution degree                                                                                                                             | 2 (IEC 1131-2/EN 61131-2)                                                                                                                                                        |
| Free space around Adept MV controller and power chassis (for proper cooling)                                                                 | 25 mm (1-inch) in front,<br>15 mm (1/2-inch) at top                                                                                                                              |
| Robot protection class                                                                                                                       | IP20 (NEMA Type 1)<br><br>A robot that meets IP54 standards is available. See “IP 54 Adept-XL Robot” on page 273.                                                                |
| Controller and power chassis subassembly protection class, unmounted                                                                         | IP20 (NEMA Type 1)                                                                                                                                                               |
| Recommendations for customer-supplied enclosure for Adept controller and power chassis. (Mandatory for installations in EU or EEA countries) | Enclosure should meet EN 60204 (IEC 204) requirements and be rated at IP54. Also, enclosure must provide a method of locking the enclosure power-disconnect in the OFF position. |
| <b>NOTE:</b> See Chapter 11 for robot, Adept MV controller, and PA-4 power chassis dimensions.                                               |                                                                                                                                                                                  |

## 2.4 Power Requirements

### Adept MV Controller Power Requirements

Table 2-3. Adept MV Controller Power Requirements

| Auto-Ranging<br>Nominal<br>Voltage Ranges,                                                             | Minimum<br>Operating<br>Voltage <sup>a</sup> | Maximum<br>Operating<br>Voltage | Frequency/<br>Phasing | Recommended<br>External Circuit<br>Breaker<br>(user-supplied) |
|--------------------------------------------------------------------------------------------------------|----------------------------------------------|---------------------------------|-----------------------|---------------------------------------------------------------|
| 100V to 120V<br>and<br>200V to 240V                                                                    | 90V<br><br>180V                              | 132V<br><br>264V                | 50-60Hz,<br>1-phase   | 10 amps                                                       |
| Power to the Adept MV controller and all amplifiers and motion devices must come from a single source. |                                              |                                 |                       |                                                               |

<sup>a</sup> The maximum interruption time (operating voltage below specification) tolerated by the controller is 16 milliseconds.

### Facility Overvoltage Protection

The user must protect the controller from excessive overvoltages and voltage spikes. If the country of installation requires a CE-certified installation, or compliance with IEC 1131-2, the following information may be helpful: IEC 1131-2 requires that the installation must ensure that Category II overvoltages (i.e., line spikes not directly due to lightning strikes) are not exceeded. Transient overvoltages at the point of connection to the power source shall be controlled not to exceed overvoltage Category II, i.e., not higher than the impulse voltage corresponding to the rated voltage for the basic insulation. The user-supplied equipment or transient suppressor shall be capable of absorbing the energy in the transient.

In the industrial environment, nonperiodic overvoltage peaks may appear on mains power supply lines as a result of power interruptions to high energy equipment (such as a blown fuse on one branch in a 3-phase system). This will cause high current pulses at relatively low voltage levels. The user shall take the necessary steps to prevent damage to the controller system (such as by interposing a transformer). See IEC 1131-4 for additional information.

## PA-4 Power Chassis Power Requirements

**Table 2-4. Adept PA-4 Power Chassis Power Requirements<sup>a</sup>**

| Nominal Voltage Range                                                                   | Frequency/ Phasing            | Minimum Operating Voltage | Maximum Operating Voltage | Recommended External Circuit Breaker (user-supplied) |
|-----------------------------------------------------------------------------------------|-------------------------------|---------------------------|---------------------------|------------------------------------------------------|
| 380 to 415 VAC                                                                          | 50-60Hz, 3-phase with neutral | 342 VAC                   | 424 VAC                   | 20 amps                                              |
| 200 to 240 VAC                                                                          | 50-60Hz, 3-phase              | 180 VAC                   | 245 VAC                   | 20 amps                                              |
| Power to the Adept MV controller and PA-4 power chassis must come from a single source. |                               |                           |                           |                                                      |

<sup>a</sup> Specifications for the Adept power chassis are based on two A and one B+ amplifier modules and an Adept-XL robot.

## 2.5 Before Unpacking the Adept Equipment

Carefully inspect all shipping crates for evidence of damage during transit. If any damage is indicated, request that the carrier's agent be present at the time the container is unpacked.

## 2.6 Adept Shipment Specifications

Adept ships the equipment in a number of boxes and shipping crates, depending on the sales order. The boxes have different dimensions and weights. The following table gives an overview.

**Table 2-5. Adept Shipping Crate Specifications**

| Product in Crate                           | Length          | Width           | Height          | Weight          |
|--------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| AdeptOne-XL Robot                          | 0.74 m (29 in.) | 1.20 m (47 in.) | 2.00 m (79 in.) | 265 kg (583 lb) |
| AdeptThree-XL Robot                        | 0.74 m (29 in.) | 1.20 m (47 in.) | 2.00 m (79 in.) | 266 kg (585 lb) |
| Adept MV Controller and PA-4 Power Chassis | 0.89 m (35 in.) | 0.64 m (25 in.) | 0.96 m (38 in.) | 66 kg (145 lb)  |
| Monitor                                    | 0.54 m (21 in.) | 0.51 m (20 in.) | 0.51 m (20 in.) | 23 kg (50 lb)   |



**WARNING:** The center of gravity of the robot shipping crates is not in the middle of the boxes. Pay attention when you transport the crates.

## 2.7 Transport and Storage

### Shipping and Storage

This equipment must be shipped and stored in a temperature controlled environment, within the range -25°C to +55°C. The recommended humidity range is 5 to 90 percent, non-condensing. It should be shipped and stored in the Adept-supplied packaging, which is designed to prevent damage from normal shock and vibration. You should protect the package from excessive shock and vibration.

Use a forklift, pallet jack, or similar device to transport and store the packaged equipment (see Figure 2-2 on page 51).



**WARNING:** Heavy load!  
Do not attempt to transport the robot boxes by hand. Always use a pallet jack, forklift, etc.

The robots must always be stored and shipped in an upright position in a clean, dry area that is free from condensation. Do not lay the crate on its side or any other position, this could damage the robot.

## 2.8 Lifting and Handling

### Before Unpacking

Carefully inspect all shipping crates for evidence of damage during transit. Pay special attention to tilt and shock indication labels on the exteriors of the containers. If any damage is indicated, request that the carrier's agent be present at the time the container is unpacked.

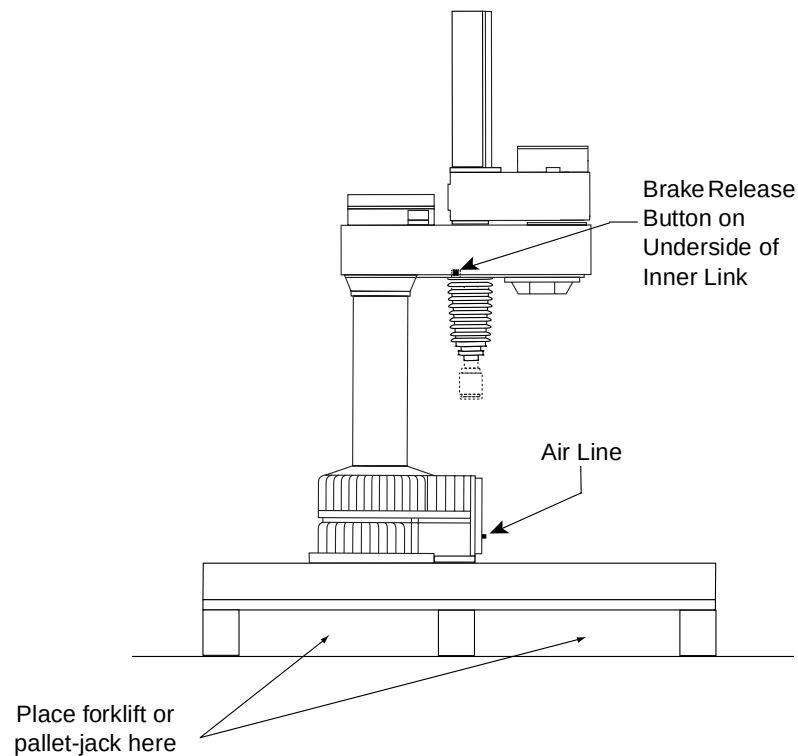


**Figure 2-2. Adept-XL Robot on a Transportation Pallet**

## **2.9 Unpacking and Inspecting the Adept Equipment**

### **Upon Unpacking**

Before signing the carrier's delivery sheet, please compare the actual items received (not just the packing slip) with your equipment purchase order and verify that all items are present and that the shipment is correct and free of visible damage.

If the items received do not match the packing slip, or are damaged, do **not** sign the receipt. Contact Adept as soon as possible.

If the items received do not match your order, please contact Adept immediately.

Inspect each item for external damage as it is removed from its container. If any damage is evident, contact Adept (see "How Can I Get Help?" on page 41).

Retain all containers and packaging materials. These items may be necessary to settle claims or, at a later date, to relocate equipment.

## **2.10 Repacking for Relocation**

If the robot or other equipment needs to be relocated, reverse the steps in the installation procedures that follow this chapter. Reuse all original packing containers and materials and follow all safety notes used for installation. Improper packaging for shipment will void your warranty. Before unbolting the robot from the plate or spool, fold the outer arm against the joint 2 hardstops to help centralize the center of gravity. The robot must always be shipped in an upright orientation. Specify this to the carrier if the robot is to be shipped.

## **2.11 Robot and Controller ID Labels**

Identification (ID) labels are located on the left or back side of the controller and power chassis. On the label you will find the model and serial numbers and the voltage and current ratings (see Figure 4-18 on page 90). Smaller serial number labels are located on the front of the chassis near the On/Off switch. The robot ID label is located on the right side of the robot base, toward the rear. You should always have this serial number available when you call Adept Customer Service for technical support.

## 3.1 Mounting the Robot

Adept robots must always be installed on a base. The base can be a mounting plate or a mounting spool (see “Mounting Surface Specifications” on page 45).



**WARNING:** You must **not** install a robot directly on the floor.

### Tool and Equipment Requirements

Common hand tools, plus the following items, are required to install the robot and any options or end-effectors:

- Power Drill Motor, 12 mm (1/2-inch) capacity, minimum
- Masonry drill bit, 22 mm (7/8-inch)
- Ratchet handle, 1/2-inch drive
- Socket, 3/4-inch
- Device for measuring mounting surface level that exceeds the level requirements described in Table 2-1 on page 45.
- Torque wrench, 1/2-inch drive
- Vacuum cleaner
- Pallet jack (or forklift)
- Hydraulic lift with dual-leg sling (both rated for 320 kg [700 pounds] minimum)
- Mounting plate or spool



**WARNING:** The installation procedures in this chapter should be performed only by skilled persons, as defined in section 1.12 on page 39. Do not attempt the installation without proper tools, including a torque wrench and a device for measuring level. An improper installation could cause serious damage or possible fatal injury.

## Installing a Base for the Robot

Adept recommends that you use a mounting plate or a mounting spool. The following sections detail preparing and installing a plate or a spool. The plate or spool must meet the specifications detailed in "Mounting Surface Specifications" on page 45.

### Robot Installation Dimension Drawings

Figure 3-1 shows the dimensions for drilling the holes to mount the plate or spool to the floor.

Figure 3-2 shows the hole pattern for drilling the holes to mount the robot to the plate or spool.

Figure 3-3 shows the clearance required at the rear of the robot for the power and signal cables.

Figure 3-4 shows mounting plate installation details.

Figure 3-5 shows mounting spool installation details.

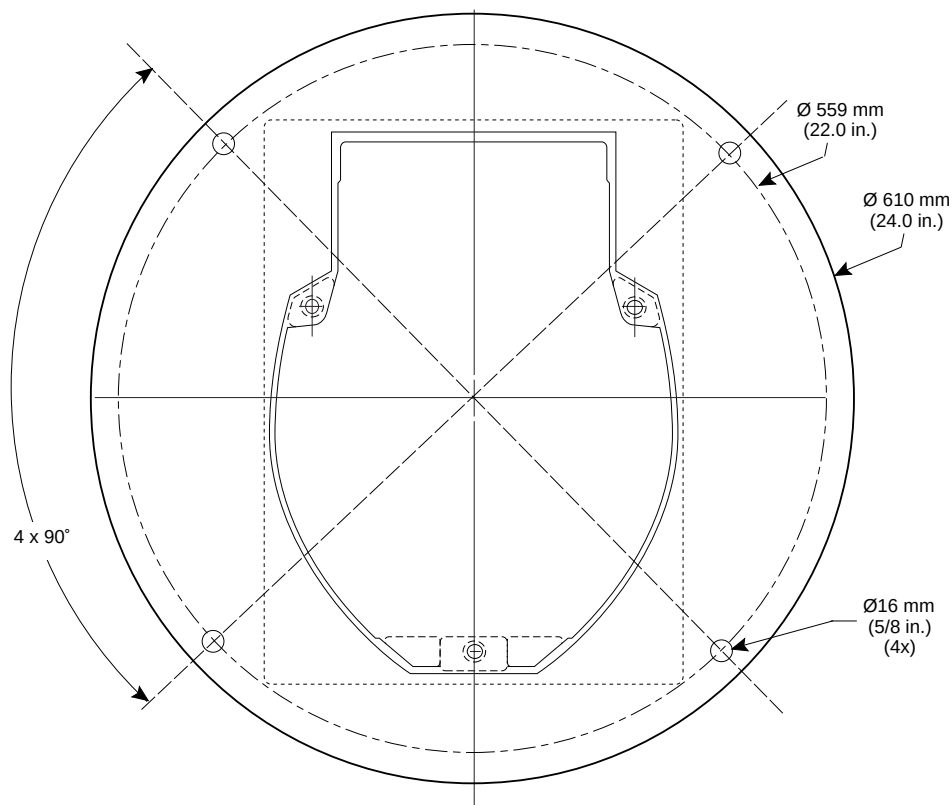


**Figure 3-1. Mounting Hole Pattern (Plate/Spool-to-Floor)**

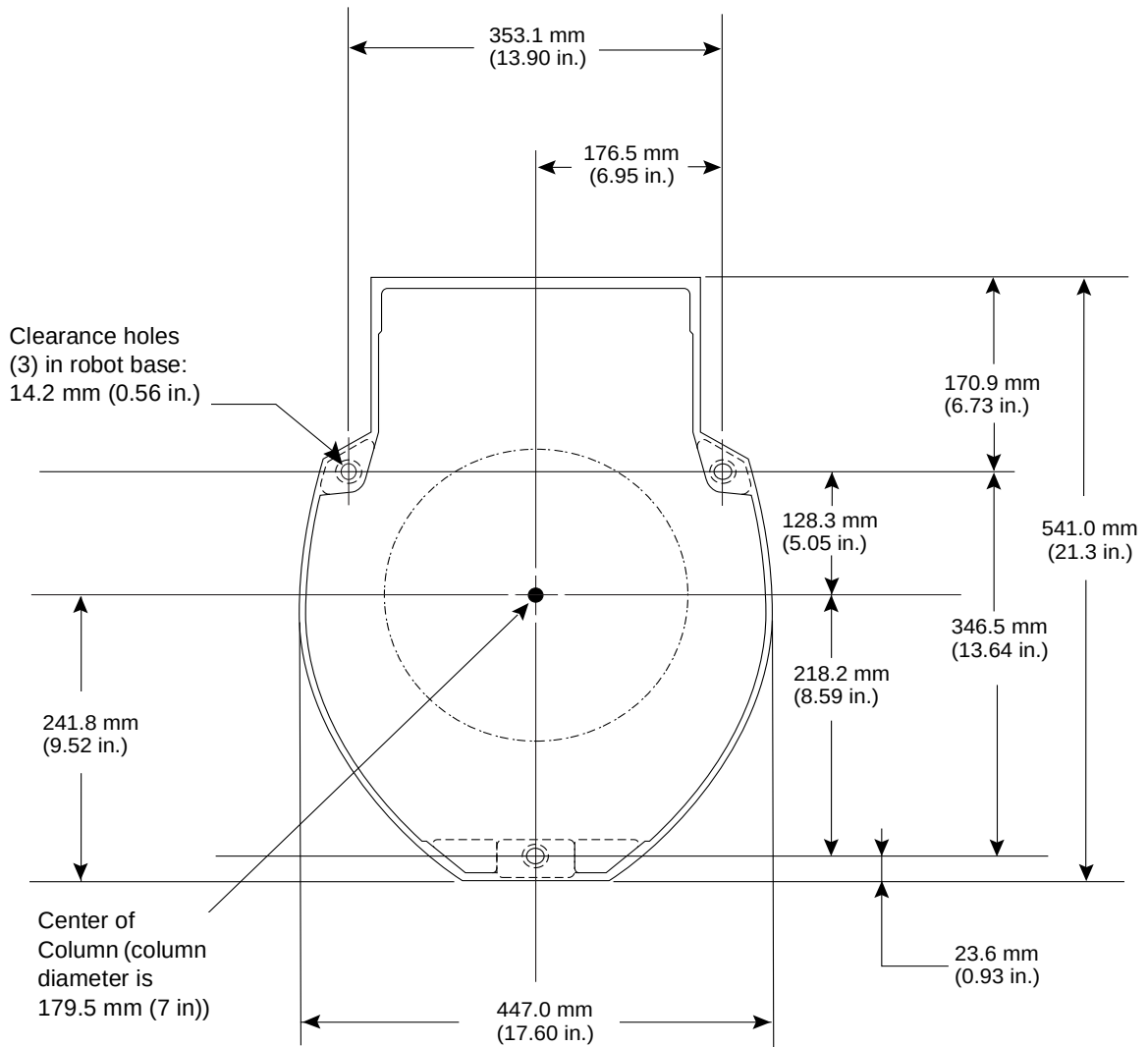


**Figure 3-2. Mounting Hole Pattern (Robot-to-Plate/Spool)**

## Required Robot Arm and Signal Cable Clearance

At least 254 mm (10 in) of clearance is required behind the robot so the power and signal cables do not have excessively tight bends.

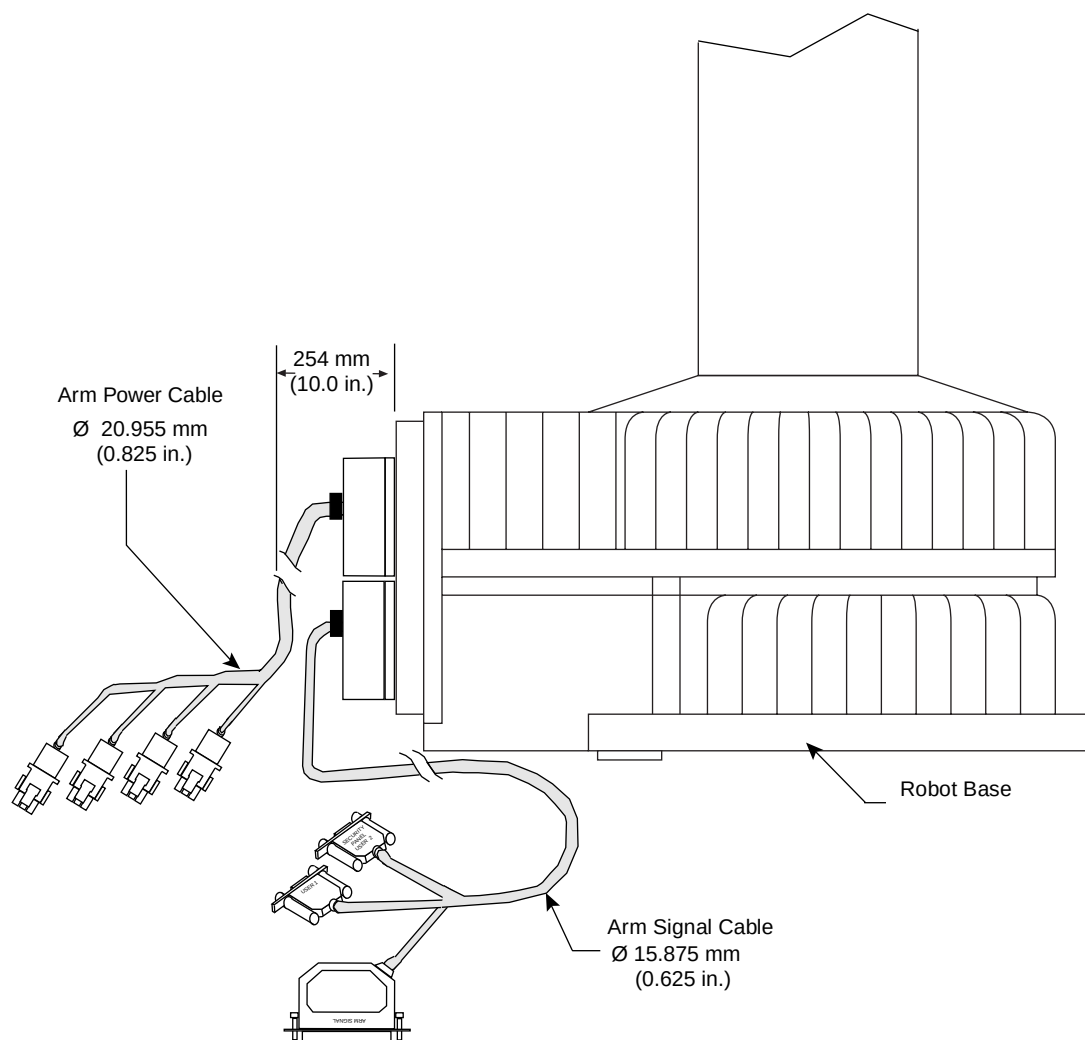


Figure 3-3. Required Clearance for Robot Cables

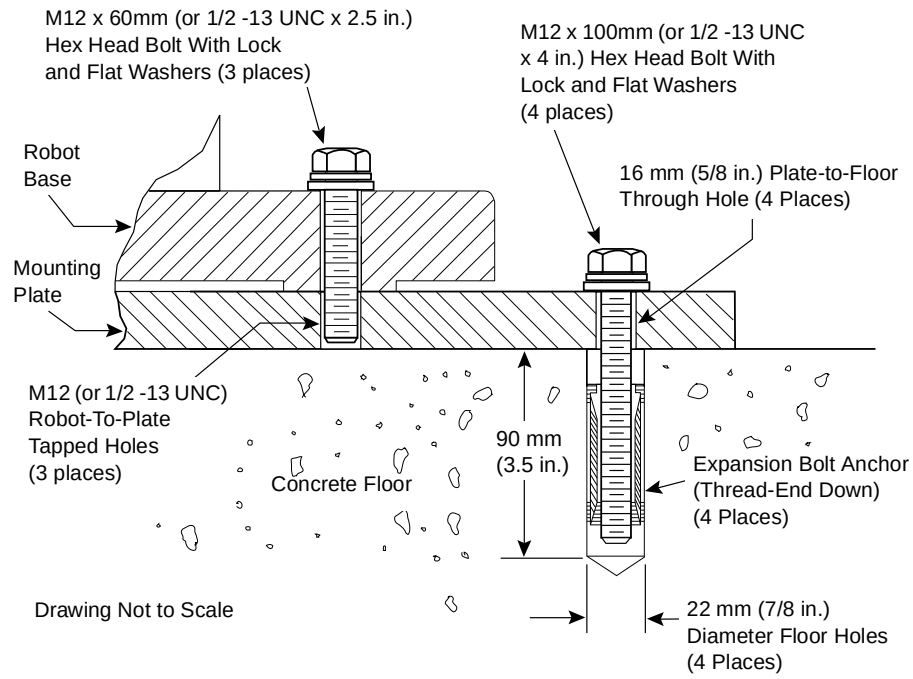


**Figure 3-4. Mounting Plate-to-Floor Installation Detail**

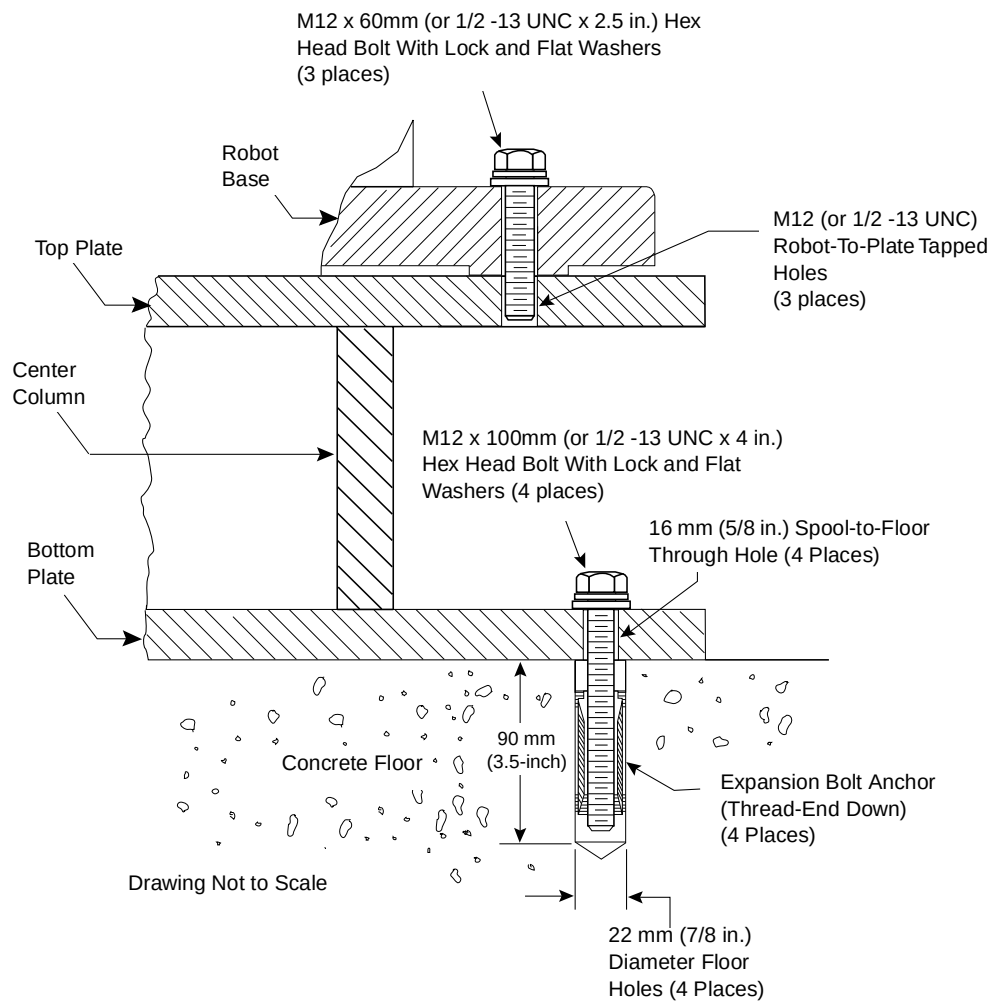


**Figure 3-5. Mounting Spool-to-Floor Installation Detail**

### Installing a Mounting Plate

The following sequence details the installation of a robot-mounting plate to the floor:

**NOTE:** You can substitute M12 bolts of correct length in place of 1/2-13 UNC bolts to install the mounting plate and robot.

1. Drill and tap three M12 (or 1/2-13 UNC-2B) mounting holes, as shown in Figure 3-2, for robot-to-plate attachment.
2. Drill four 16 mm (5/8-inch) diameter through holes, as shown in Figure 3-1, for plate-to-floor anchoring.
3. Place the plate exactly where the robot is to be installed. Ensure that the plate is positioned so that the “footprint” for the robot is properly oriented relative to the workcell. Using the plate as a template, transfer the locations of the four plate-to-floor mounting holes directly to the floor.

4. Set the plate aside and drill four holes, 22 mm (7/8-inch) in diameter by 90 mm (3.5 inches) deep, in the floor at the locations identified in step 3.
5. Using a vacuum cleaner, remove all chips and debris from the holes, drilled in step 4, and surrounding area.
6. Insert an expansion bolt anchor into each of the four holes in the floor. Ensure that the threaded end of each bolt anchor is toward the bottom of each hole, as shown in Figure 3-4.
7. Reposition the plate over the anchor holes in the floor using care to align the four plate-to-floor holes with the anchor holes. Ensure that the plate is positioned so that the “footprint” for the robot is properly oriented to the workcell.
8. Verify that the top (mounting) surface of the plate is level (ensure that the accuracy of the device used to level the plate exceeds the required leveling tolerances). The surface must be horizontal within  $\pm 0.25$  degrees (MMSP), or  $\pm 0.3$  degrees (no MMSP). If the plate is not level, insert shims between the plate and the floor to bring the plate within specifications. The shims should be at least 75 mm (3 inches) in diameter and have cutouts provided to fit around the anchor bolts.
9. Insert a M12 x 100 mm (or 1/2 - 13 UNC x 4-inch) bolt, fitted with a lock washer and a flat washer, through the holes in the plate into each of the four plate-to-floor anchor holes. Tighten the bolts to 55 N•m (40 ft-lb) of torque.
10. Recheck the robot mounting surface of the plate and reinsert shims as required to bring the mounting surface horizontal within  $\pm 0.25$  degrees (MMSP), or  $\pm 0.3$  degrees (no MMSP).

### Installing a Mounting Spool

The following sequence details the installation of the robot-mounting spool to the floor (see Figure 3-5).

**NOTE:** You can substitute M12 bolts of correct length in place of 1/2-13 UNC bolts to install mounting spool and robot.

1. Drill and tap three M12 (or 1/2-13 UNC-2B) mounting holes (through) in the top of the spool, as shown in Figure 3-2, for robot-to-spool attachment.
2. Prepare the bottom of the mounting spool by drilling four 16 mm (5/8-inch) diameter through holes, as shown in Figure 3-1, for spool-to-floor anchoring.
3. Place the spool exactly where the robot is to be installed. Ensure that the spool is positioned so that the footprint for the robot is properly oriented to the workcell. Transfer the locations of the four spool-to-floor mounting holes directly to the floor.
4. Set the spool aside and drill four holes, 22 mm (7/8-inch) in diameter by 90 mm (3.5-inch) deep, in the floor at the locations identified in step 3.
5. Using a vacuum cleaner, remove all chips and debris from the holes, drilled in step 4, and surrounding area.
6. Insert an expansion bolt anchor into each of the four holes in the floor. Ensure that the threaded end of each bolt anchor is toward the bottom of each hole, as shown in Figure 3-5.

7. Reposition the spool over the anchor holes in the floor taking care to align the four spool-to-floor holes with the anchor holes. Ensure that the spool is positioned so that the “footprint” for the robot is properly oriented to the workcell.
8. Verify that the top (mounting) surface of the plate is level (ensure that the accuracy of the device used to level the plate exceeds the required leveling tolerances). The surface must be horizontal within  $\pm 0.25$  degrees (MMSP), or  $\pm 0.3$  degrees (no MMSP). If the spool is not level, insert shims between the spool and the floor to bring the spool within specifications. The shims should be at least 75 mm (3 inches) in diameter and have cutouts provided to fit around the anchor bolts.
9. Insert a M12 x 100 mm (or 1/2-13 UNC x 4-inch) bolt, fitted with a lock washer and a flat washer, through the holes in the spool into each of the four spool-to-floor anchor holes. Tighten the bolts to 55 N•m (40 ft-lb) of torque.
10. Recheck the robot-mounting surface of the spool and reinsert shims as required to bring the mounting surface horizontal within  $\pm 0.25$  degrees, or  $\pm 0.3$  degrees without MMSP.

## Mounting a Robot on a Base

The following sequence describes the installation of the robot to the mounting plate or spool.

**NOTE:** You can substitute M12 bolts of correct length in place of 1/2-13 UNC bolts to install mounting spool and robot.

1. Connect the hydraulic lift to the eyebolts at the top of the robot by means of a dual-leg sling; see Figure 3-6. Take up any slack, but do not lift the robot.



**WARNING:** Impact Hazard!

Do not attempt to lift the robot at any points other than the eyebolts provided. Failure to comply could result in the robot falling and causing either personnel injury or equipment damage.

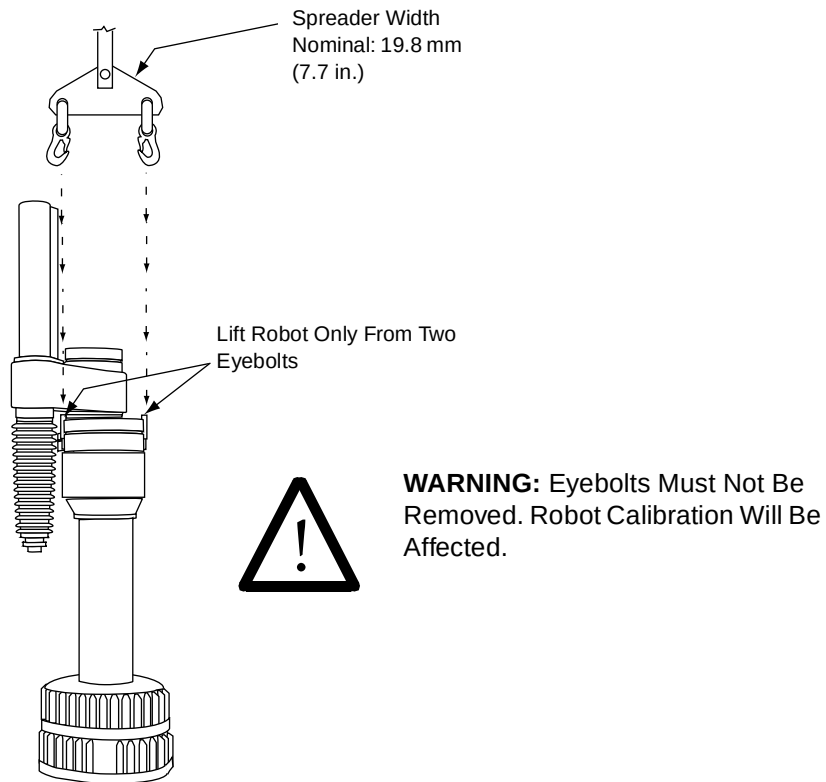


**Figure 3-6. Lifting Robot With Eyebolts**

2. Remove the three bolts securing the robot base to the pallet. Retain these bolts for possible later relocation of the equipment.



**WARNING:** Do not extend the inner or outer links of the robot until the robot has been secured in position. With the inner and outer links extended, an unsecured robot will tip and fall causing either personnel injury or equipment damage.

3. Lift the robot and position it directly over the floor plate or spool.



**WARNING:** Impact Hazard!

The robot may swing free if not lifted straight up. Stand clear of the robot at all times while it is supported by the lift.

4. Slowly lower the robot while aligning the base and the tapped mounting holes in the plate or spool. Do not remove the permanent eyebolts.
5. Insert a M12 x 60 mm (or 1/2 -13 UNC x 2.5-inch) bolt fitted with both a lock washer and a flat washer through each of the three mounting holes in the robot base into the mounting plate or spool and torque to 90 N•m (65 ft-lb).
6. Install the air filter provided in the installation kit and connect to a compressed air source that meets the requirements detailed in "Compressed Air Requirements" on page 44.

## 3.2 Using the Brake Release Button

### Brakes

The Adept-XL robot has fail-safe, spring-actuated, air release brakes on joints 1, 2, 3, and 4. These brakes are engaged whenever High Power is off. The brakes are intended primarily to restrict arm movement when high power is off, but they also assist in stopping robot motion when the emergency stop circuitry is activated or when there is a robot motion error. These brakes are not designed to routinely stop the robot.

### Brake Release Button

To manually position the arm without turning on High Power, a brake release button is located on the joint 1 inner link. The brake release button releases all four joints of the Adept-XL robot (see Figure 2-2 on page 51).

The brake release function works only if a compressed air supply is connected to the robot. The brake release function does not need electrical power and will work even if the controller is turned off or is not connected to the robot.

## 3.3 Limiting Joint Travel

The joint motion or travel is limited by both software and hardware limits. The program-mable software limits are known as softstops; the fixed hardware limits are referred to as hardstops. See Table 11-2 on page 261 for the AdeptOne-XL and Table 11-4 on page 263 for the AdeptThree-XL.

### Softstops

Softstops are used when the normal motion range of the robot must be limited (if other equipment is installed inside the envelope, for example). The softstops for each joint are set to their maximum value at the factory. To limit any joint's motion range, change the joint's softstop value using the SPEC utility program on the Adept Utility Disk supplied with the system. Refer to the *Instructions for Adept Utility Programs* for information regarding this utility program.

When you are using the MCP to move the robot, the robot will stop abruptly when it encounters a softstop. This abruptness does not mean a hardstop has been contacted.

### Hardstops

In most cases, the softstop will prevent joint travel from contacting a hardstop; however, contact is possible during high-speed operation. The hardstops are designed to withstand large forces without damaging the robot.

The hardstops for each joint are fixed mechanical stops. The hardstops for joints 1 and 3 are located inside the robot. The hardstops for joint 2 are mounted externally on the inner link. The joint 2 hardstops are the hard rubber half-cylinders that the large eyebolts pass through. The hardstops for joint 3 are mounted at the top and bottom of the quill. Joint 2 and 3 hardstops must not be modified in any way or damage to the robot could occur.

## Cartesian Limit Stops

V<sup>+</sup> can detect collisions between the robot end-effector and static Cartesian obstacles. V<sup>+</sup> tests for collisions between the robot's tool tip, or its tool-mounting flange, and specified obstacles.

**NOTE:** Collisions between other structural elements of the robot and the obstacles, or between two robots, are NOT detected.

For fixed structural elements of the workcell, the system automatically detects possible collisions in the following circumstances:

- When planning the end point for a straight-line or joint-interpolated motion
- When executing a straight-line motion (but not during a joint-interpolated motion)
- When moving the robot in tool, world, or joint manual control

Rectangular solids (boxes), cylinders, and spheres can be defined. Objects can be placed in any position and orientation relative to the base of the robot.

Four user obstacles can be defined and modified by the end user. The SPEC utility (see SPEC.V2 in the *Instructions for Adept Utility Programs*) is used to define obstacles.



# Adept MV Controller Installation 4

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The Adept-XL robots are delivered with either an Adept MV-5 controller or an Adept MV-10 controller. The dimensions, installation, and cabling requirements of both controllers are identical. The Adept MV-10 controller allows for additional option boards. The following sections apply whether you have an Adept MV-5 or Adept MV-10 controller. The same PA-4 power chassis is used with both controllers.

The controller chassis holds the backplane, power supply, and cooling fans required by the various processor boards. All systems include an AWC system processor (see Figure 4-1) and an EJI motion interface board (see Figure 4-15). These boards are delivered with the configuration specified on your order and you should not have to perform any setup or initialization of these boards. If you need to alter the delivered configuration or are installing additional boards not supplied with the original order, see the *Adept MV Controller User's Guide* for complete details on installing and configuring boards.

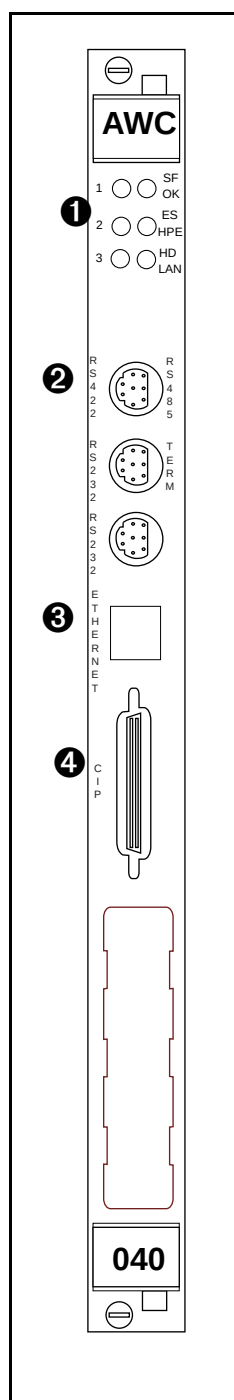
Your system may contain additional optional boards that were included as part of your sales order. These boards also will be configured as ordered and you should not have to perform any additional setup or configuration. For a complete description of all Adept processor boards, see the *Adept MV Controller User's Guide*. The optional boards that might be in your system are:

- Additional AWC boards used as auxiliary processors
- EVI board for the AdeptVision system
- VGB board for the standard Adept graphical user interface
- SIO board for additional hard and floppy drives and additional serial ports
- MI6/MI3 boards for controlling non-Adept robots
- DIO for supplying additional digital input and out signals

The amplifier chassis holds the backplane, power distribution, and cooling fans required by the amplifiers. An amplifier chassis for an Adept-XL series robot contains two single-channel amplifiers (described in “A Amplifier Module Overview” on page 67) and one dual-channel amplifier (described in “Dual B+ Amplifier Module Overview” on page 68).

## AdeptWindows Controller (AWC) Board Connectors and Indicators

An AWC board (040 or 060) is required in every system. This section describes the basic features of the AWC board.



### 1 Status LEDs.

Six bicolor LEDs indicate diagnostic test, power control, and communication status.

The right column of LEDs gives the following status information:

| LED Label | Red LED            | Green LED          |
|-----------|--------------------|--------------------|
| SF/OK     | System Fault       | System O.K.        |
| ES/HPE    | E-Stop open        | High Power Enabled |
| HD/LAN    | Read/Write from CF | Ethernet access    |

During system startup the red SF/OK and ES/HPE LEDs are lit and the red HD/LAN LED blinks. After system startup, the SF/OK LED should show green. If the ES/HPE LED shows red, the E-Stop circuit is open. During compact flash reads and writes, the HD/LAN LED pulses red. When the AWC is active on an Ethernet network, the HD/LAN LED pulses green. See Table 8-1, "LED Status Indicators," on page 183 for details on the LEDs labeled 1 - 3.

- 2 Two RS232 ports and one RS422/485 port (see the *Adept MV Controller User's Guide* for pin descriptions and locations).
- 3 Ethernet connector: Shielded RJ45 receptacle that supports 10 BaseT communications (see the *Adept MV Controller User's Guide* and the *AdeptNet User's Guide*).
- 4 Controller Interface Panel (CIP) connector that accepts a standard 50-pin SCSI cable that routes signals and information to the CIP. Note that the CIP does not communicate in SCSI format (see sections 4.2 through 4.5 for basic installation details. See the *Adept MV Controller User's Guide* for complete details.

Figure 4-1. AWC System Processor Board

## A Amplifier Module Overview

The A amplifier module is a plug-in module that contains the circuitry and amplifying components to drive the joint-1 or joint-2 motor in an Adept-XL robot. In this type of robot system, there are two A amplifier modules in the Adept PA-4 power chassis. The A amp module on the left-hand side, called Amp #1, drives the motor for joint 1. The A amp module on the right-hand side, called Amp #2, drives the motor for joint 2.

### Connectors and Indicators

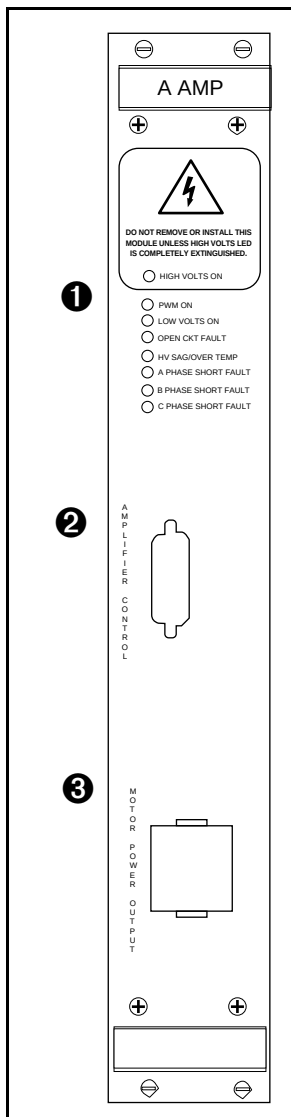


Figure 4-2. A Amplifier

- ① Status LEDs. When an LED is turned on it indicates the following conditions:

**High Volts On** indicates the high voltage to the amps is turned on.

**PWM On** indicates that current servo is on. It does not go on until calibration is complete.

**Low Volts On** indicates the low voltage supply in the power chassis is on.

**Open Ckt Fault** indicates that an open circuit in the motor leads has been detected.

**HV Sag/Over Temp** indicates that the input voltage has dropped below the specified level or an over-temperature fault has been detected on an amp module.

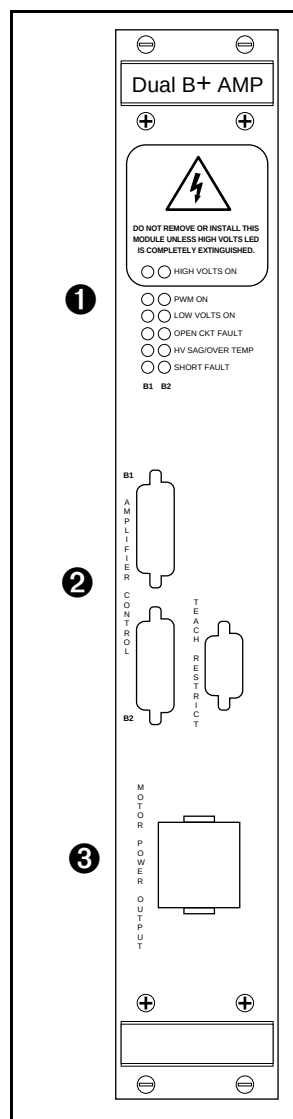
**Phase A, B, C Short Fault** indicate that an over-current in the motor leads to one of the phases has been detected.

- ② **Amplifier Control** connector – the EJI-to-Amp cable connector is installed here.
- ③ **Motor Power Output** connector – the Arm Power cable is installed here.

## Dual B+ Amplifier Module Overview

The Dual B+ amplifier module is a plug-in module that contains the circuitry and amplifying components to drive two robot motors. In this type of robot system, there is one Dual B+ amplifier module in the Adept PA-4 power chassis. This amp module, located to the right of the A amp modules, drives the motors for joints 3 and 4.

### Connectors and Indicators



- ❶ Status LEDs. The left-hand column of LEDs is for the first motor controlled by this module; the right-hand column is for the second motor controlled by this board. When an LED is turned on it indicates the following conditions:

**High Volts On** indicates the high voltage to the amps is turned on.

**PWM On** indicates that current servo is on. It does not go on until calibration is complete.

**Low Volts On** indicates the low voltage supply in the power chassis is on.

Note: the three LED pairs below indicate faults and are visible momentarily before the system turns off.

**Open Ckt Fault** indicates that an open circuit in the motor leads has been detected.

**HV Sag/Over Temp** left-hand LED, when lit, indicates that the fault was caused by a sag in voltage. The right-hand LED when lit indicates the fault was caused by an over-temperature condition on the amplifier heat sink.

**Short Fault** indicates that an over-current in the motor leads has been detected.

- ❷ **Amplifier Control** connector – the EJI-to-Amp cable connectors are installed here.  
**Teach Restrict** connector – the Teach Restrict-to-B+ Amp cable is installed here.
- ❸ **Motor Power Output** connector – the Arm Power cable is installed here.

Figure 4-3. Dual B+ Amplifier

## 4.1 Mounting the Adept MV Controller and Power Chassis

**NOTE:** The Adept MV controller must be installed in a suitable enclosure that provides the environment (temperature, etc.) specified in Table 2-2, “Robot System Operating Environment Requirements,” on page 47 and complies with applicable local and national regulations.

The enclosure must also provide a power disconnect with a method for user service personnel to lock the power in the OFF position. This is required for safety, including national and international standards, such as:

- OSHA ‘Lockout/Tagout’ (USA)
- IEC 204-1
- EN 60204-1



**WARNING:** Failure to provide and use a suitable disconnect device could cause death or injury to personnel.

### Joining an Adept PA-4 Power Chassis to an Adept MV Controller

The Adept PA-4 power chassis can be joined to an Adept MV controller using the brackets and screws supplied in the accessory kit. Join the chassis and controller at the top *and* bottom, as described in the following paragraphs.

**NOTE:** Joining the chassis and controller allows rack mount of the chassis and controller in a 19-inch rack.

### Joining at the Top

1. Turn off power to each unit and disconnect the power cord. Place the two units next to each other. Remove the top cover from both (see Figure 4-4).
2. Locate the C-shaped bracket in the accessory kit.
3. Slip the bracket under the lip of the top edge of the unit on the right-hand side and into the two slots in the edge of the chassis. Install two M4 x 8 mm flat-head screws into the lip and down into the bracket.
4. Install the other two M4 x 8 mm flat-head screws into the chassis on the left-hand side. Replace the cover on each unit.

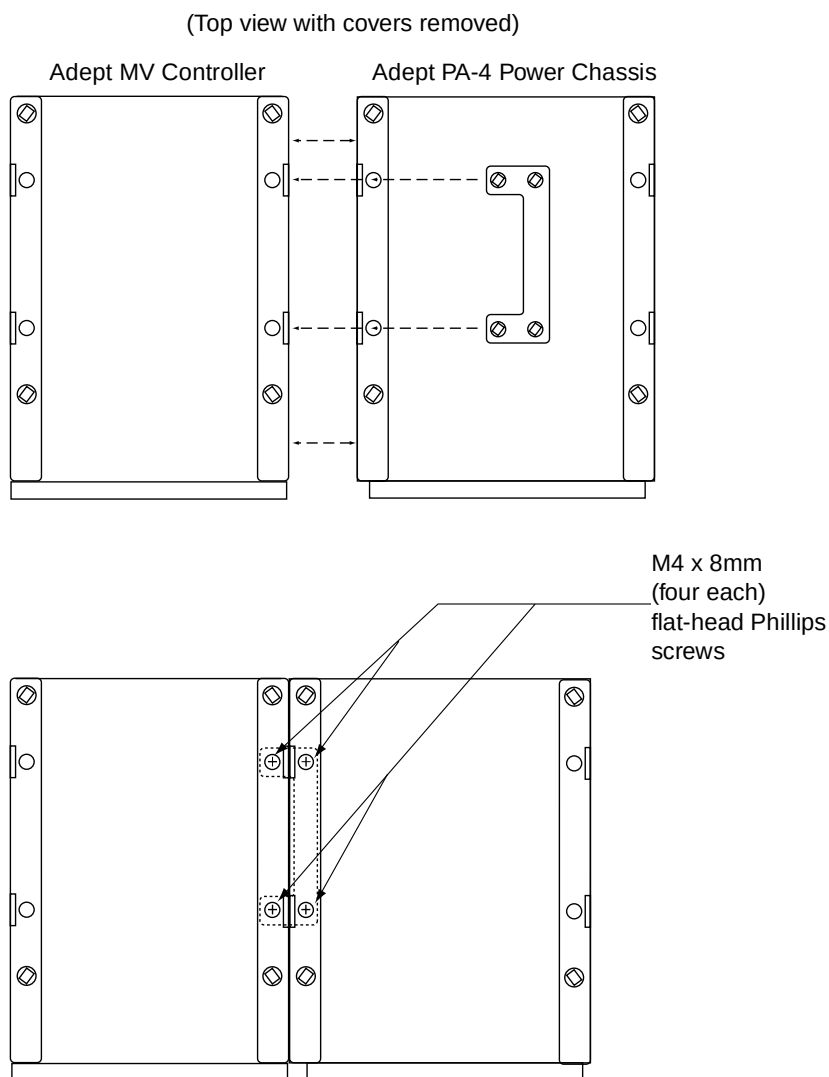


**Figure 4-4. Joining the Power Chassis and Controller at the Top**

### Joining at the Bottom

1. Turn the two units over so you have access to the bottom side.
2. Locate the cutout bracket in the accessory kit.
3. Place the bracket over the feet of the units as shown in Figure 4-5.
4. Install the four M4 x 8 mm flat-head screws in the holes indicated in Figure 4-5 to secure the brackets.



**CAUTION:** Do not use screws longer than 8 mm to install the bracket. Doing so could cause damage to your equipment.

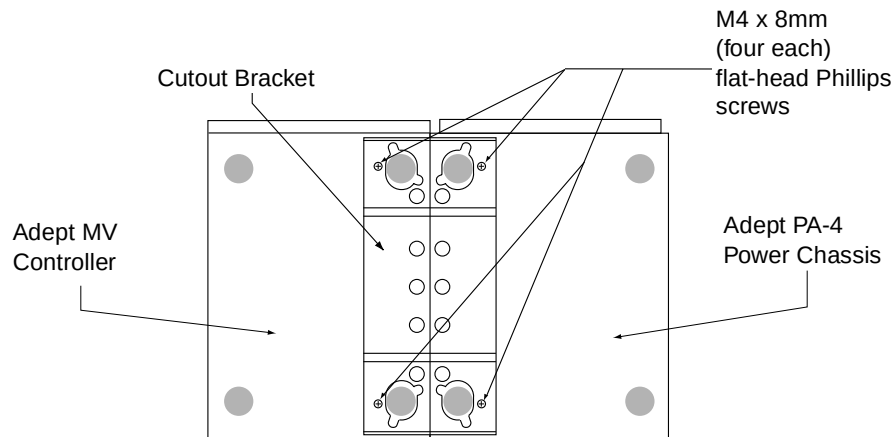


Figure 4-5. Joining the Power Chassis and Controller (Bottom View)

### Space Around the Chassis

When the controller and power chassis are installed, you must allow 50 mm (2 in) at the front of the power chassis and 25 mm (1 in) at the top and bottom of the Adept MV controller for proper air cooling.



**CAUTION:** It is important to keep the air filters clean so the forced air cooling system can work efficiently. See section 10.4 on page 228 for details on cleaning the filters.

### Rack or Panel Mounting

The power chassis and controller can be rack or panel mounted using the mounting brackets that are shipped in the accessories kit. The brackets can be attached at the rear of the controller/power chassis for panel mounting or they can be attached to the front of the controller/power chassis for rack mounting.

### **Panel Mounting**

To panel mount the controller or power chassis, install one bracket on each side near the back of the chassis. Use the screws and washers from the accessories kit (see Figure 4-6 and Figure 4-7).

### **Rack Mounting**

Use the mounting brackets, screws, and washers from the accessories kit to rack-mount the Adept PA-4 power chassis joined to an Adept MV controller in a standard 19-inch equipment rack. The brackets can be installed in two positions for rack mounting: “flush” and “set-back” (see Figure 4-6 and Figure 4-7).

To Install Mounting Brackets on an Adept MV Controller:

- Remove (and discard) three existing countersunk screws from the chassis side at locations shown in drawing.
- Place bracket in desired position and secure with indicated M4 screws and washers from the accessories kit.
- Repeat process for the other side of the controller. If the controller is joined to an Adept PA-4 power chassis, see Figure 4-7 for the location of the screws on the PA-4 power chassis.

**Note:** See Figure 11-11 on page 252 for dimensions of the controller and mounting brackets.

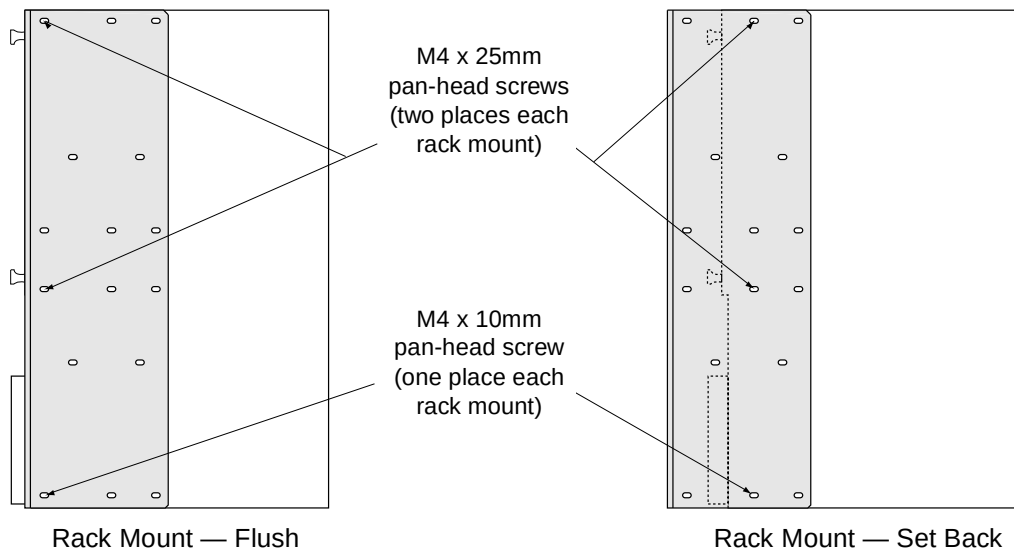
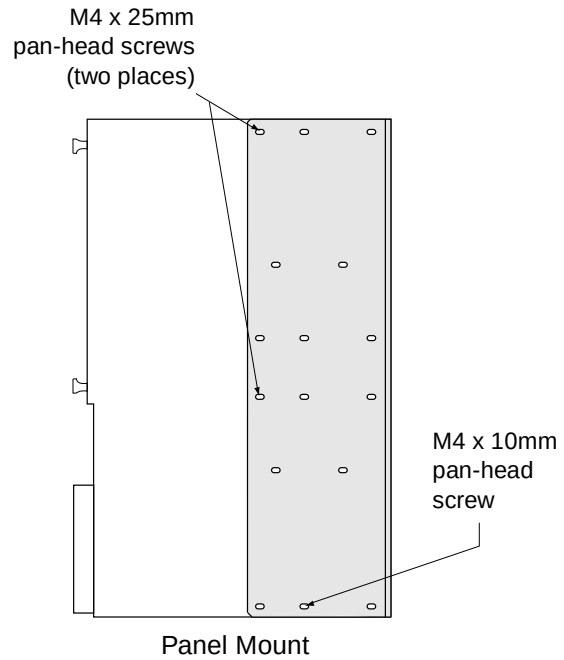


**Figure 4-6. Installing Mounting Brackets on an Adept MV Controller**

To Install Mounting Brackets on an Adept PA-4 Power Chassis:

- Remove (and discard) three existing countersunk screws from the chassis side at locations shown in drawing.
- Place bracket in desired position and secure with indicated M4 screws and washers from the accessories kit.
- Repeat process for the other side of the controller. If the controller is joined to an Adept MV controller, see Figure 4-6 for the location of the screws on the MV controller.

**Note:** See Figure 11-11 on page 252 for dimensions of the chassis and mounting brackets.

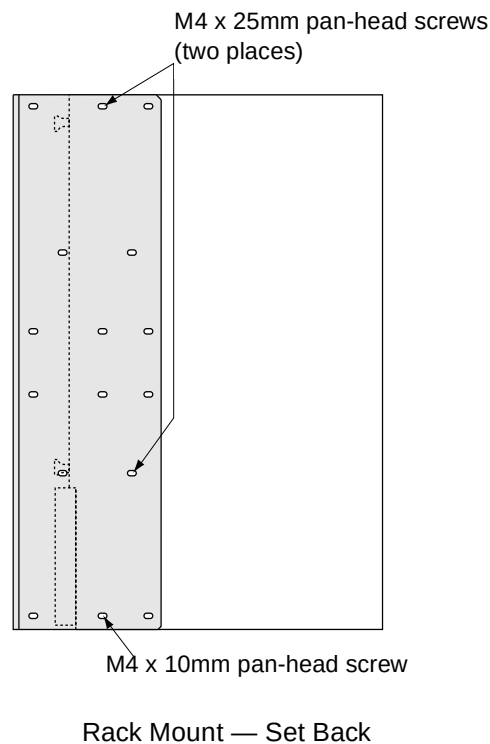
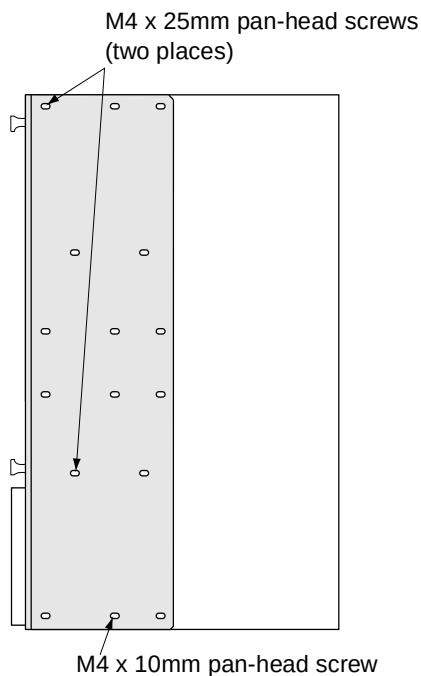
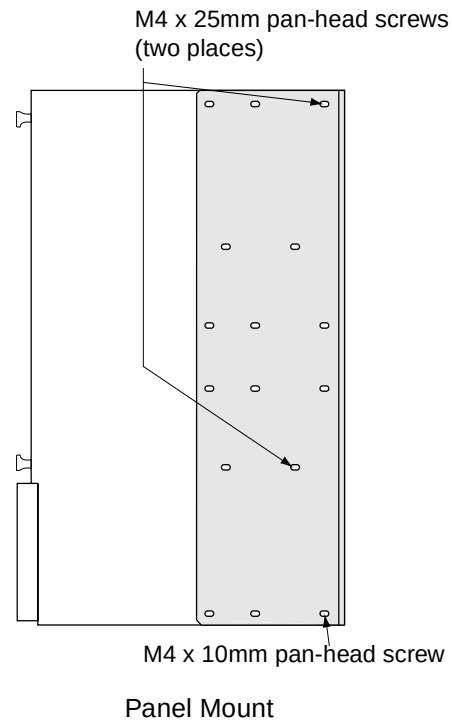


**Figure 4-7. Installing Mounting Brackets on an Adept PA-4 Power Chassis**

## 4.2 Controller Interface Panel Description

The CIP is the primary hardware interface to an Adept controller. The CIP can be face-gasket mounted (gasket not included).

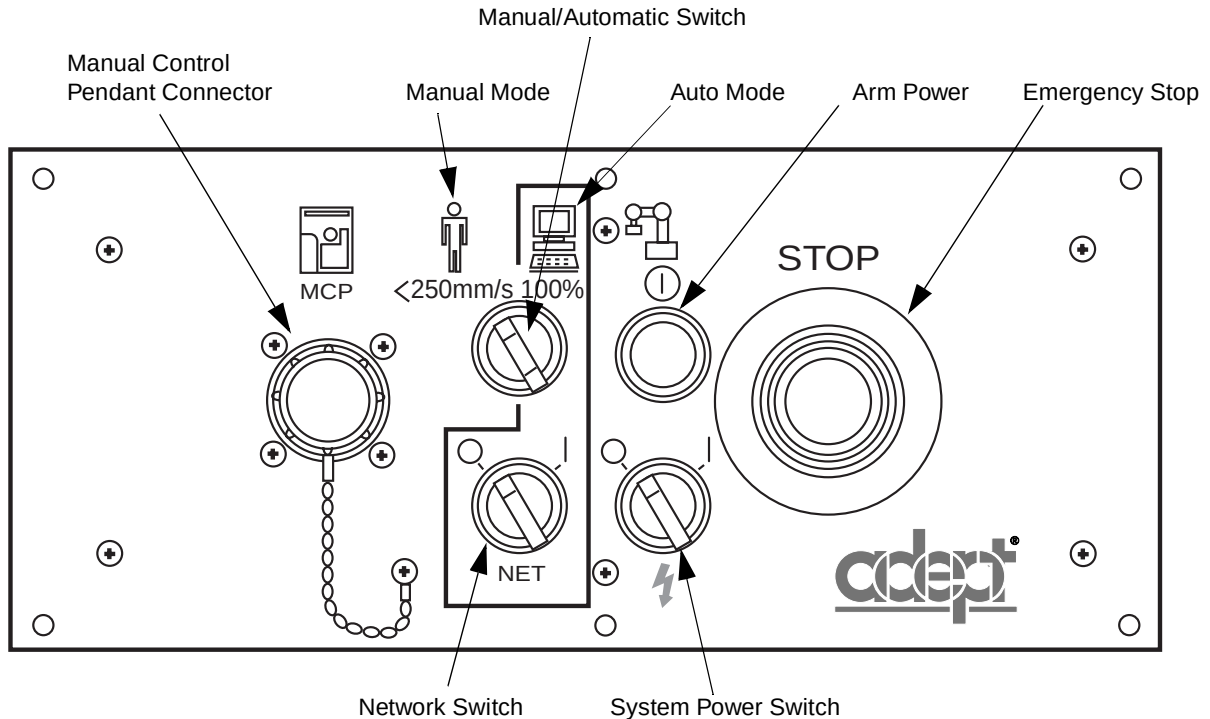


Figure 4-8. Controller Interface Panel (CIP)

### Panel Switches and Indicators

#### Emergency Stop Switch

The E-Stop is a dual channel passive E-Stop that supports Category 3 CE safety requirements. It supports a customer-programmable E-Stop delay that maintains motor power for a programmed time after the E-Stop is activated. This allows the motors to assist in stopping the robot. The programmable E-Stop is described in a paper available through Adept On Demand (see "How Can I Get Help?" on page 41).

#### Manual/Automatic Mode Switch

In Automatic (AUTO) Mode, programs running on the system control the mechanism and the mechanism can be run at full speed. In Manual Mode the system limits mechanism speed and torque so that an operator can safely work in the cell. Manual mode initiates software restrictions on robot speed, commanding no more than 250 mm/sec as required by RIA and ISO standards. For Category 3 mechanisms, such as the Adept-XL, safety regulations require that the software speed and torque limiting be enforced by hardware. This hardware must be redundant and self-testing. The Manual Mode Safety Package (MMSP) available for the Adept-XL robots implements this functionality (see Figure 4-8 for the location of the Manual/ Automatic Mode switch on the CIP).

### High Power Enabling Switch/Lamp

This switch, marked with a robot figure and the international ON symbol ( I ), controls High Power, which is the flow of current from the amplifiers to the robot motors. Enabling high power is a two-step process. An “Enable Power” request must be sent from the system terminal, an executing program, or the manual control pendant. Once this request has been made, the operator must press this button and High Power will be applied.

**NOTE:** High Power **cannot** be enabled if this lamp is burned out. See “Changing the Lamp on the CIP High Power Enable Switch” on page 230 for details.

### Manual Control Pendant (MCP) Connector

The MCP plugs into this connector. The CIP works only with the MCP III, P/N 10332-11000 (Assembly Number 90332-48050). Other Adept pendants will **not** work because they do not incorporate the dual E-Stop channels. See “Connecting the MCP to the CIP” on page 80 for details.



**CAUTION:** Damage may result if an MCP III is plugged into older Adept controller systems that contain a VME Front Panel (VFP). Damage may also result if older MCPs (part numbers other than 10332-11000) are plugged into a CIP.

### System Power Switch

This switch, marked with a lightning bolt, allows you to switch a relay or other power switching equipment to control power to the Adept controller and other equipment. The two independent, normally open contacts on this switch come out of the User connector and out of a terminal block on the MMSP. They are for customer use only. See “Connecting the System Power Switch to the CIP” on page 169 for details on using these connections.

### NET Switch

This switch should be left in the “O” position.

## Side Connectors

See Figure 4-9 on page 77 for the location of the following connectors:

### AWC Interface (JAWC)

Connects the CIP to the AWC board. The JAWC connector accepts a standard 50-pin SCSI cable (see Figure 4-11 on page 80). Note that the CIP does not communicate in SCSI format. See “Connecting the CIP to the AWC” on page 79 for details.

### User Connector (JUSER)

All switch functions on the CIP can be duplicated external to the CIP using signals from this connector. For example, an external E-Stop can be connected to the User connector; this will behave exactly like the E-Stop on the CIP. Similarly, there is an output on the User connector that can be used to stop external equipment when the CIP E-Stop is pressed (see “Remote E-Stop Circuit” on page 172 for details). See the *Adept MV Controller User’s Guide* for details on the other remote functionality available through this connector.

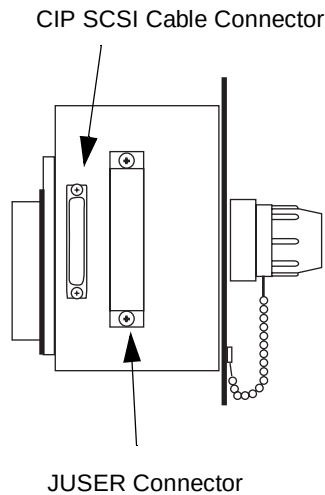


**Figure 4-9. Controller Interface Panel (CIP) Side View**

## Back Panel Connectors

See Figure 4-10 for the location of the following connectors:

### RS-232 (JCOM)

There is one RS-232 connector on the back of the CIP. It is a DB9 connector. This RS-232 has no hardware handshake lines. See “RS-232 (JCOM) Connector” on page 158 for details.

### Manual Mode Safety Package (MMSP)

The Manual Mode Safety Package (MMSP) (designed to meet CE Category 3 requirements for the Adept-XL robots) is connected here. See “Installation of the MMSP Option” on page 95 for details.

### AUX (JEXT)

This connector is reserved for Adept internal use.

### CIB (JSLV)

This connector is reserved for Adept internal use.

### DeviceNet (JDVC)

DeviceNet is a field bus for industrial devices. This standard supports a variety of products, including sensors, digital I/O, analog I/O, RS-232, and PLCs. Adept directly supports Digital I/O devices and has currently qualified DeviceNet products from Wago and Beckhoff. In the future, Adept will offer direct support for Analog I/O. Other DeviceNet product types, such as keypads and displays, can be controlled using the V<sup>+</sup> FCMD program instructions (see the V<sup>+</sup> *Language Reference Guide* for details).

See “DeviceNet Communication Link” on page 156 and the *Adept MV Controller User’s Guide* for details on DeviceNet installations.

## Digital I/O Connections

There are 44 digital inputs and 40 digital outputs available on the CIP. See “Connecting User-Supplied Digital I/O Equipment” on page 173 for details. Additional digital I/O can be added using DIO boards. See the *Adept MV Controller User’s Guide* for details.

**JSIO** This connector includes 20 signal pairs; eight digital outputs (100 mA max) and 12 digital inputs, including four fast inputs (the first four input signals on this connector are the only input signals that can be configured as fast inputs). The digital outputs are short-circuit protected. The single channel E-Stop input, and passive E-Stop output are also included on this connector.

**NOTE:** With the MMSP option, input signal 1012 and output signals 1 through 5 are not available. The remaining signals from the JSIO connector are also available at terminal blocks on the Security Panel (see “Digital Signals on the Category 3 E-Stop Board” on page 121). These signals can be wired from either the CIP or the Security Panel.

**JDIO 1-4** These four connectors duplicate the function of one DIO board with 32 inputs and 32 outputs (700 mA max.), a total of 64 I/O points. The digital outputs are short-circuit protected and protected from thermal overload. Note that if a DIO board is installed and addressed as DIO board #1, the JDIO connectors on the CIP are inactive. In order to use the JDIO signals, the first DIO board must be addressed as DIO board #2. See the *Adept MV Controller User’s Guide* for details on DIO boards.

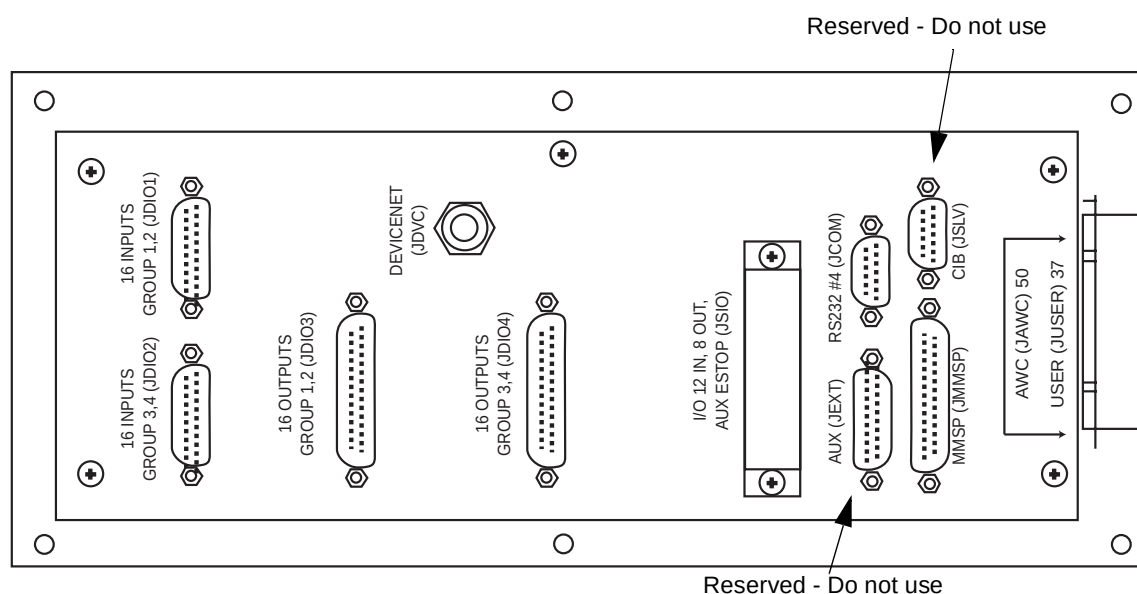


Figure 4-10. Controller Interface Panel (CIP) Back Panel View

## 4.3 Mounting the Controller Interface Panel (CIP)

All the user connections to the AWC, except for the serial ports and the Ethernet connectors, are made through the CIP. The CIP provides connections for digital I/O, fast inputs, one RS-232 serial port, DeviceNet, and the user interface to the E-Stop circuitry. See “Connecting Customer-Supplied Safety and Power Control Equipment to the CIP” on page 161 for details on connecting user E-Stop circuitry. See the *Adept MV Controller User’s Guide* for details on the other connections.

### Location of the CIP

The CIP contains features that prevent dangerous motions while an operator is in the workcell. In order for the installation of the CIP to conform with RIA and European standards for power control functions, the CIP must be mounted outside the robot enclosure. Mount the CIP on the same enclosure as the controller, or on a separate, protected enclosure (see section 11.1 for CIP dimensions).

## 4.4 Connecting the CIP to the AWC

The CIP connects to the AWC through the JAWC connector. The AWC to CIP cable is a 1.8 m (6 ft.) SCSI-2 50-wire cable with a male Micro D50-pin shielded connector on each end. The Micro D-connector has two rows of 25 pins spaced at 1.27 mm (0.050 inches) apart.

To connect the CIP to the AWC (see Figure 4-11 on page 80):

1. Turn off the Adept MV controller power switch, and disconnect main power.
2. Plug one end of the CIP interface-panel cable into the CIP connector on the AWC board. Plug the other end into the SCSI connector (JAWC) on the left side of the CIP. Be sure the spring latches are engaged.
3. When not using the MCP, install the optional MCP bypass plug into the MCP connector on the face of the CIP. If an MCP is being used, see “Connecting the MCP to the CIP” on page 80 for more information.
4. In order to enable High Power, plugs with appropriate jumpers or contacts must be attached at the JSIO and JUSER connectors.

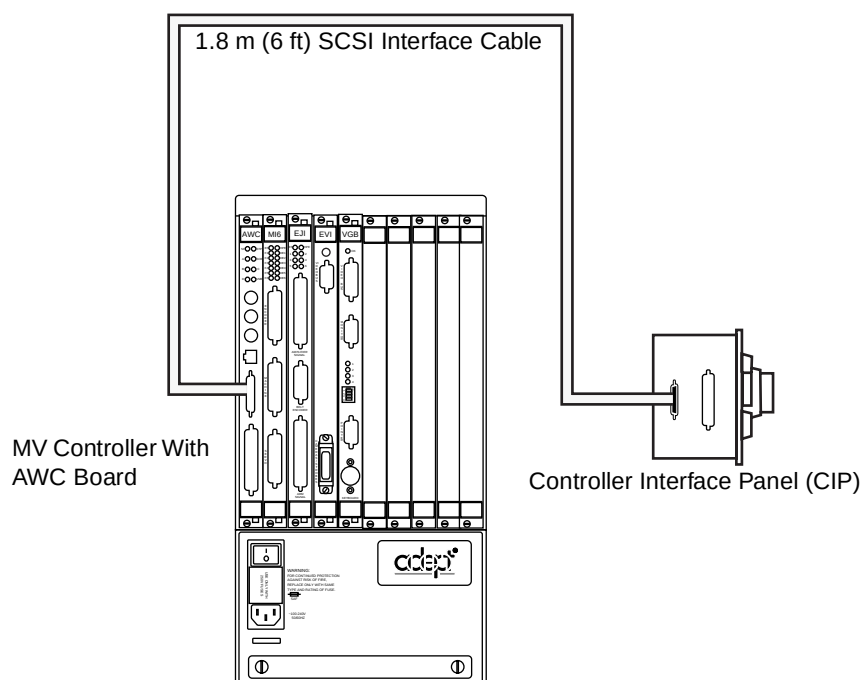


Figure 4-11. Connecting the CIP to the AWC

### Extended Length CIP-to-AWC Cable

A custom cable, not to exceed 10 m (33 ft.), may be fabricated. It should be made to the ANSI SCSI Parallel Interface 2 (SPI-2) standard and should incorporate twisted pair wires of a minimum of 0.08 mm<sup>2</sup> (28 AWG) size. The connectors should be wired so that pin 1 goes to pin 1, pin 2 goes to pin 2, and so on. The twisted pairs in the cable must be wired to physically opposing contacts in the connector. That is, the first twisted pair goes to pins 1 and 26, the second to pins 2 and 27 and so on. A shielded Micro D50 male connector should be used on both ends. The entire cable must be shielded with a foil and drain wire. See the *Adept MV Controller User's Guide* for the connector pin descriptions and locations.

## 4.5 Connecting the MCP to the CIP

The MCP is connected to the system at the pendant connector on the CIP. The controller does not have to be turned off to connect or disconnect the MCP. Note that if the MCP or the MCP bypass plug is removed, High Power will be turned off. The JUSER connector allows you to install a remote MCP connector. See "Connecting User-Supplied Digital I/O Equipment" on page 173 and the *Adept MV Controller User's Guide* for details.



**WARNING:** The CIP has two key switches. Before the MCP can be used in the workcell, the operating key switch must be set to MANUAL and the NET switch to LOCAL (O). This will prevent program execution from being started from keyboard or terminal.



**CAUTION:** The coiled cable on the MCP III has been tested to withstand 500V of repetitive electrical bursts per EN61000-4-4. Exposing the MCP to voltages higher than 500V may cause the robot to shut down. In this event, it may be necessary to unplug, then reconnect, the MCP to restart the robot.



**CAUTION:** Damage may result if an MCP III is plugged into older Adept controller systems that contain a VME Front Panel (VFP). Damage may also result if older MCPs (part numbers other than 10332-11000) are plugged into a CIP.

Plug the MCP into the connector marked MCP on the CIP. The jack and plug are keyed to ensure proper connection. The CIP connector is an AMP 16-pin circular plastic male connector. A female connector is used on MCP cable.

## MCP Cradle

The MCP is stored in the MCP cradle when it is not being held by an operator. The cradle has a retaining clip that keeps the enabling switch closed. The MCP cradle *must* be installed outside of the robot workcell. See Figure 11-13 on page 254 for the dimensions of the cradle.

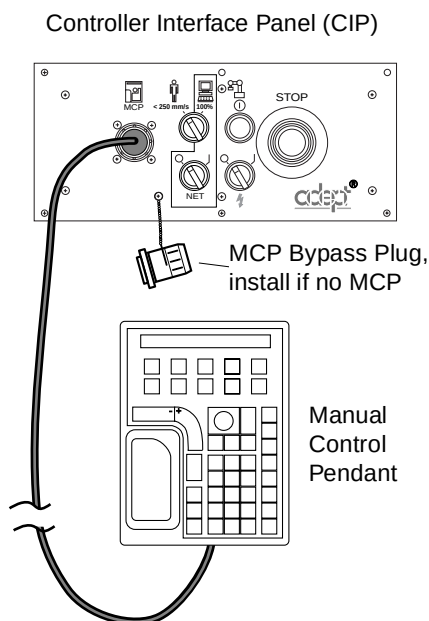


Figure 4-12. MCP Connection

## MCP Bypass Plug

The MCP Bypass plug is optional and must be installed when not using the MCP. The Adept part number for this bypass plug is P/N 10335-01060.

## 4.6 Robot and Control System Cable Installation

This section covers the installation of all required power and signal cables for the robot and controller. If you have the MMSP option, there are additional cables that must be installed. For MMSP equipped systems, complete the installation steps in this chapter up to section 4.10 on page 92, then move to Chapter 5 for details on installing the MMSP option and completing cable installation. Figure 4-13 shows the cabling between the robot and the control system. Table 4-1 lists the lengths of all cables.

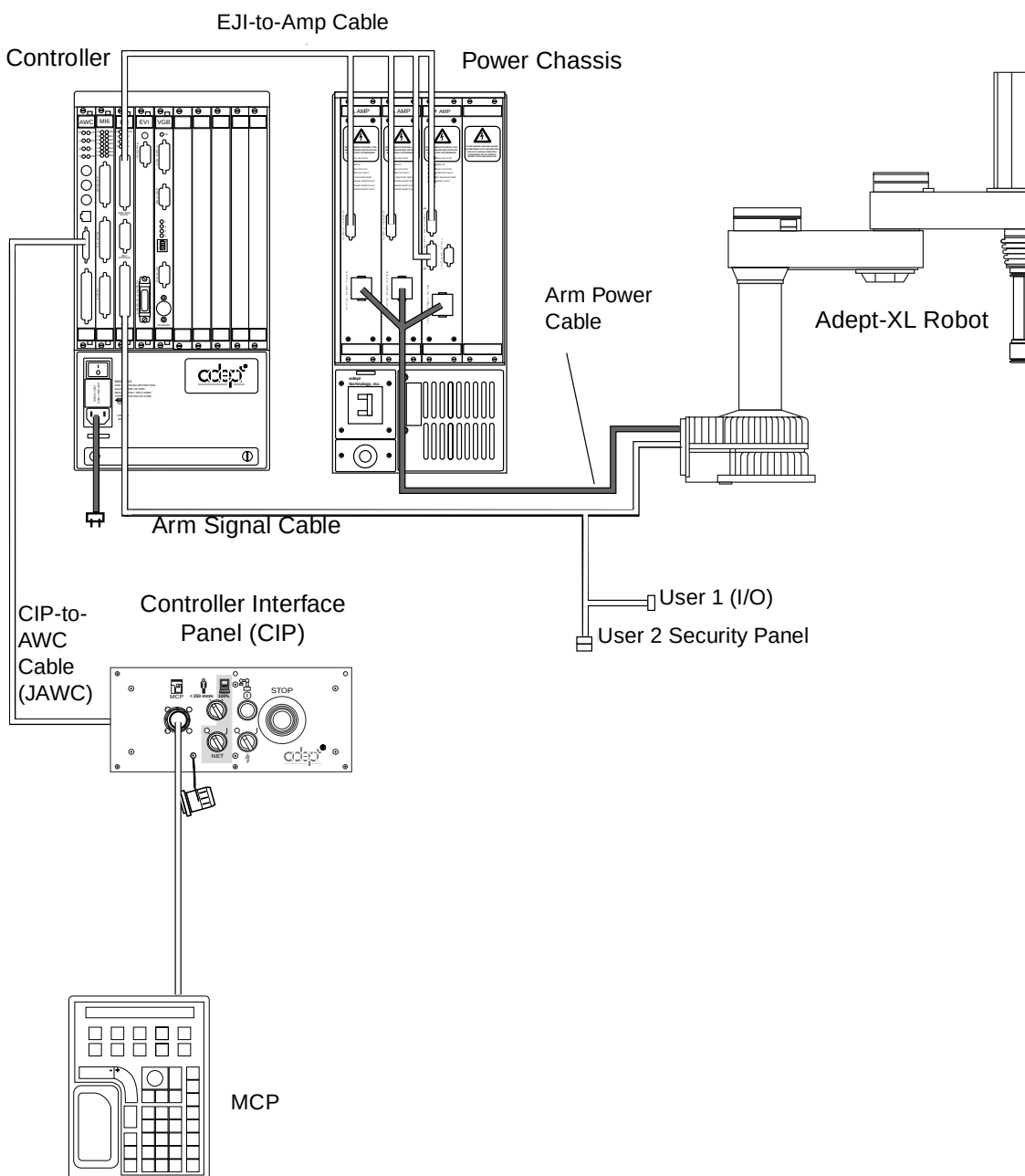


Figure 4-13. Cable Installation (Without MMSP Option)

## System Cable Lengths

**Table 4-1. System Cable Lengths**

| Cable                                      | Length                                                              |
|--------------------------------------------|---------------------------------------------------------------------|
| Arm Power and Arm Signal                   | Standard 5 m (16.5 ft)<br>Optional 8 m (26.3 ft) and 15 m (49.3 ft) |
| EJI-to-Amp                                 | MV-10 = 1 m (3 ft)                                                  |
| JSIO-to-Cat3 ESTOP (MMSP Option)           | 3.0 m (10 ft)                                                       |
| CIP-to-Cat3 ESTOP (MMSP Option)            | 3.0 m (10 ft)                                                       |
| User-to-ESTOP/Teach Restrict (MMSP Option) | 1.8 m (6 ft)                                                        |
| Teach Restrict-to-B+ Amp (MMSP Option)     | 1.8 m (6 ft)                                                        |
| Controller Interface Panel (CIP-to-AWC)    | 2 m (6.5 ft)                                                        |
| PA-4 Power Cord                            | 2.9 m (9.5 ft)                                                      |
| Adept MV Power Cord                        | 3 m (10 ft)                                                         |
| MCP Cable                                  | 1.6 m (5.4 ft)                                                      |

## Connecting the Robot to the Power Chassis

The cable between the robot and power chassis is called the Arm Power cable. The robot end of the cable has a large rectangular Harting connector with four slotted screws. The opposite end of the cable has three separate square 9-pin connectors that go to the power chassis (see Figure 4-14 on page 84). The fourth connector is not used.

1. Connect the Harting connector of the Arm Power cable to the Arm Power interface on the back plate of the robot. Verify that an O-ring gasket is in place to seal the Harting connector to the electrical bulkhead. Tighten the four captive screws securely. Make sure that there is at least 254 mm (10 in.) behind the electrical bulkhead for cable clearance. See Figure 4-14 on page 84.
2. Connect the other end of the Arm Power cable to the matching connectors on the A and B+ Amplifier boards (see Figure 4-13 on page 82):

**NOTE:** The user must add adequate strain relief for the Arm Power cable connectors at the amplifier boards.

- a. Connect the plug labeled “A Amp #1” to the connector marked “Motor Power Output” on the A amp at the left side of the chassis.
- b. Connect the plug labeled “A Amp #2” in the connector marked “Motor Power Output” on the second A amp (to the right-hand side of the first A amp).

- c. Connect the plug labeled “B+ Amp #1” in the connector marked “Motor Power Output” on the B+ amp.
- d. The fourth connector on the motor power cable is used only for the Adept-XL Fifth-Axis option (not available for robots with the MMSP option).



**WARNING:** Verify that all connectors are secure and fully inserted. Failure to do this could cause unexpected robot motion.

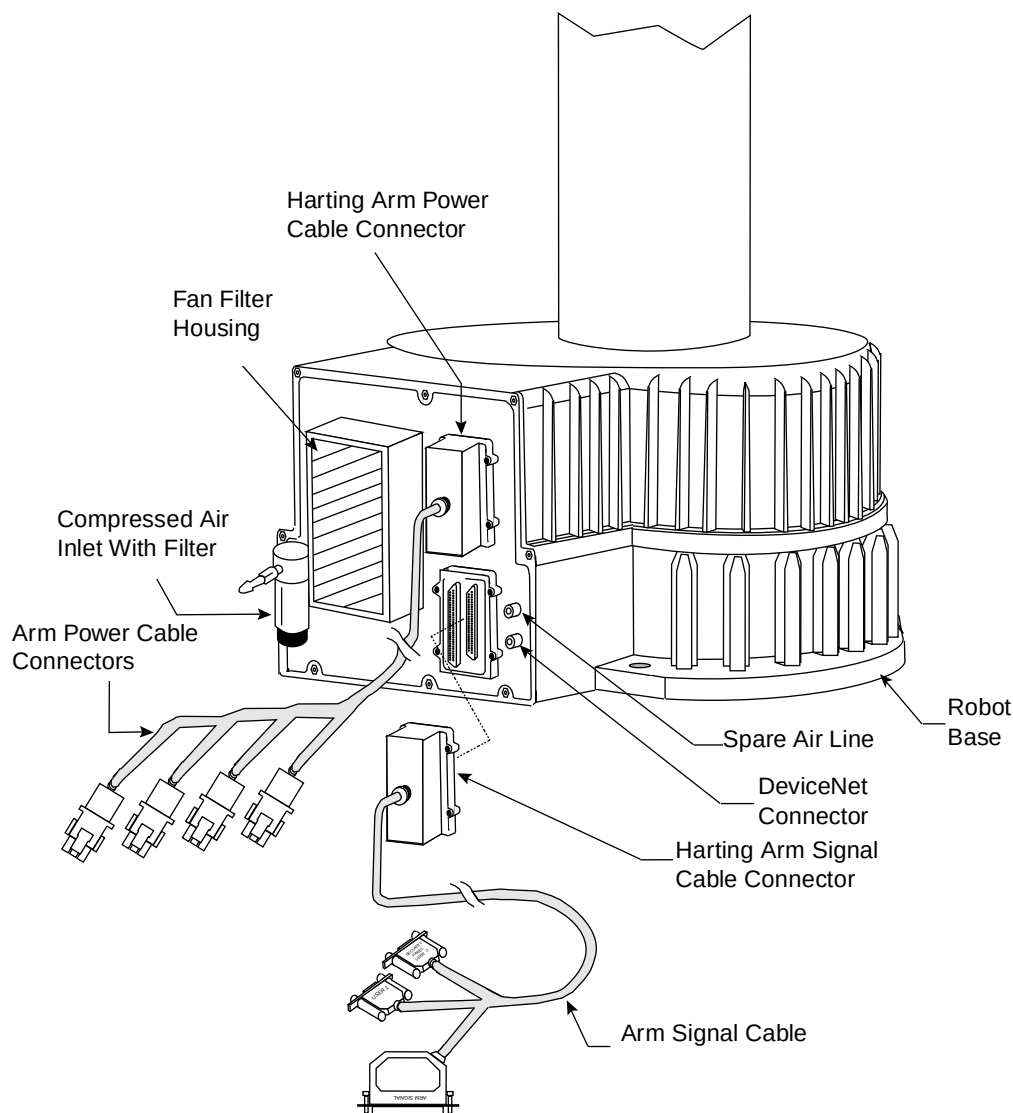


Figure 4-14. Adept-XL Robot Connector Locations

## Connecting the Robot to the MV Controller

The cable between the robot and the EJI board in the Adept MV controller is called the Arm Signal cable. The robot end has a large rectangular Harting style connector. The controller end has a 50-pin D-sub connector and two smaller 15-pin D-sub connectors. See Figure 4-13 on page 82 and Figure 4-14 on page 84.

1. Connect the Harting style connector of the Arm Signal cable to the Arm Signal/User interface on the back plate of the robot. Verify that an O-ring gasket is in place to seal the Harting connector to the electrical bulkhead. Tighten the four captive screw securely.
2. Connect the 50-pin D-sub connector to the Arm Signal connector (lower) on the EJI board. Tighten the two captive screws securely. See Figure 4-15.
3. The 15-pin D-sub connectors are labeled “User 1” and “Security Panel/User 2”. These connectors are for user-supplied equipment mounted on the robot arm or tool flange; see Chapter 7. The MMSP option requires the Security Panel/User 2 connector and these lines are not available when the MMSP is installed.



**WARNING:** Verify that all connectors are fully inserted and screwed down. Failure to do this could cause unexpected robot motion. Also, a connector could be pulled out or dislodged unexpectedly.

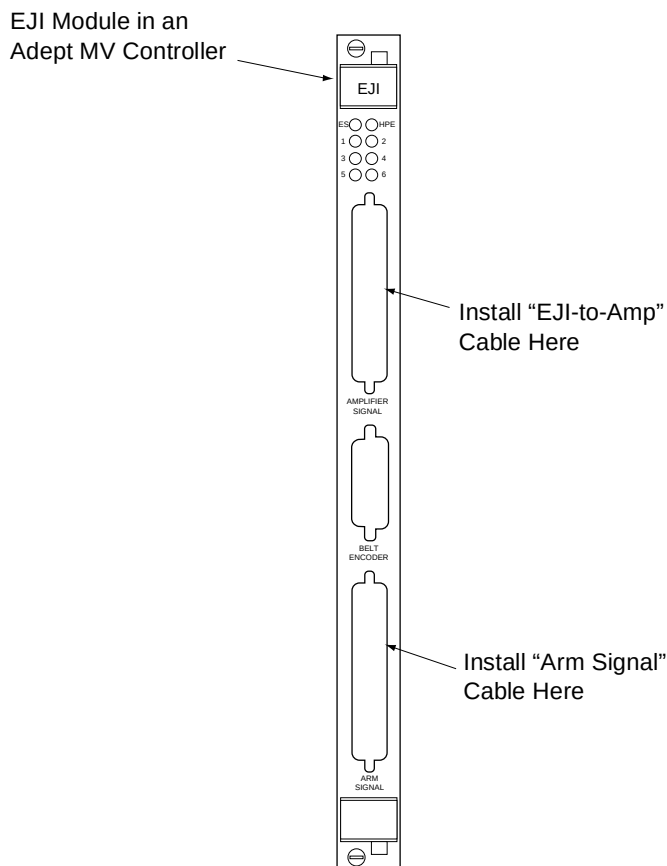


Figure 4-15. Robot-to-EJI Cable Installation

## Connecting the Adept MV Controller to the Power Chassis

The EJI-to-Amp cable connects the controller to the power chassis. This cable assembly has a single plug on one end (for the EJI) and four plugs on the other end (for the amplifiers).

1. Connect the cable end with the 50-pin connector to the connector marked Amplifier Signal on the EJI board (see Figure 4-15).
2. Connect the cable end with four plugs in the following pattern:
  - a. Connect the plug labeled “Amplifier Ctrl 1” to the Control Signal connector on A amp #1. Tighten the two captive screws securely.
  - b. Connect the plug labeled “Amplifier Ctrl 2” to the Control Signal connector on A amp #2. Tighten the two captive screws securely.
  - c. Connect the plug labeled “Amplifier Ctrl 3” to the B1 Control Signal connector on the B+ amp. Tighten the two captive screws securely.
  - d. Connect the plug labeled “Amplifier Ctrl 4” to the B2 Control Signal connector on the B+ amp. Tighten the two captive screws securely.
3. Verify that all connectors are secure, fully inserted, and installed in the correct location.



**WARNING:** Verify that all connectors are fully inserted and screwed down. Failure to do this could cause unexpected robot motion. Also, a connector could be pulled out or dislodged unexpectedly.

## 4.7 Connecting AC Power to the Adept MV Controllers

The Adept MV controllers have auto-ranging power supplies that operate at either 100-120VAC or 200-240VAC single phase. The power supply must meet the requirements detailed in Table 2-3, “Adept MV Controller Power Requirements,” on page 48.

### Power Entry Board

The power entry board is located on the front of the controller. It contains:

- On/Off power switch ( **I** = On, **O** = Off)
- Fuse holder containing the two incoming AC line fuses (The spare fuses are stored in the fuse holder; see Figure 4-16.)
- AC power cord socket

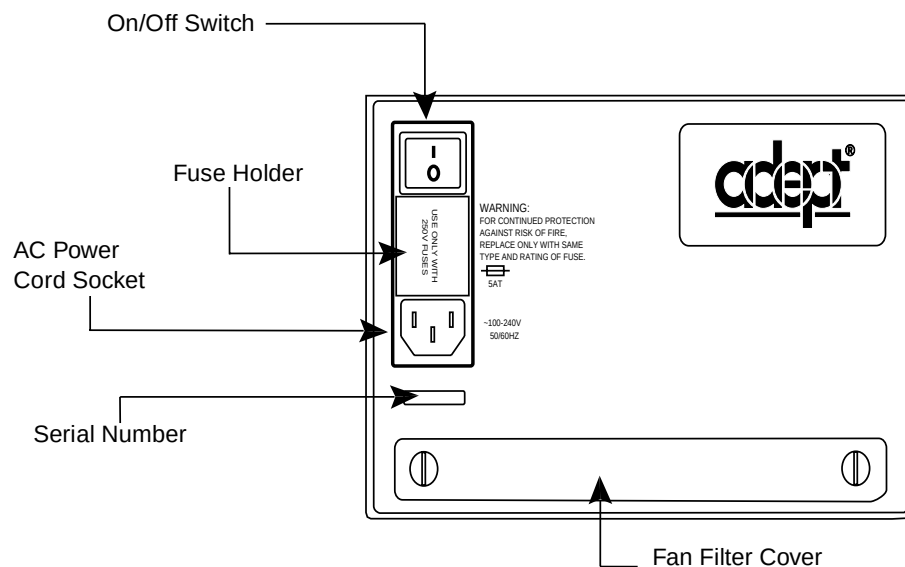


Figure 4-16. Adept MV Controller Power Entry Board

### Connecting AC Power Cord

The AC power cord is included in the accessory kit. The controller end of the power cord is fitted with an IEC 320 connector.

**WARNING:** Electrical hazard!



The installation of the power cord must be done by a skilled person. The power supply can injure or kill the person who installs the cord. An incorrect installation can injure or kill anybody who touches the equipment in the robot workcell.

Connect each conductor of the power cord securely to your AC power source, using the color code below. You must provide a suitable plug or other facility connection in accordance with all applicable local and national standards and regulations. See section 4.11 on page 93 for important information on system grounding.

**Table 4-2. Adept MV Controller Power Cord Specifications**

|                                          |                                                 |
|------------------------------------------|-------------------------------------------------|
| Cord length                              | 3 meters $\pm 0.1$ m (9 ft. 10 in. $\pm 4$ in.) |
| Cord rating                              | 10 amps                                         |
| Number and size of conductors            | 3 x 1.00 mm <sup>2</sup>                        |
| Color code:<br>line<br>neutral<br>ground | <br>brown<br>blue<br>green/yellow               |

### System Grounding Information

The detachable three-wire power cord is used for connection to both the power source and protective ground. The protective ground conductor (colored green/yellow) in the power cord is internally connected to the exposed metal parts of the Adept MV controller. To ensure electrical-shock protection, the protective ground conductor must be connected to a properly grounded power source. See section 4.11 on page 93 for proper grounding procedures.



**WARNING:** Ensure that a proper protective ground connection exists before turning on the power.

## 4.8 Manual Mode Safety Package Installation

If you are installing a system that includes the MMSP option, skip the remainder of this chapter and go to Chapter 5 to continue with the system installation. The remaining sections in this chapter are for systems that do not include the MMSP option.

## 4.9 Changing the Power Chassis Voltage Setting

This section covers changing the voltage selection for systems that do not have the MMSP option. If you are installing a system with the MMSP option, see Chapter 5.

### Changing From 380-415 VAC to 200-240 VAC

Complete the following procedure to change the AC voltage setting from 3-phase 380-415VAC to 3-phase 200-240VAC. (Also see “Connecting AC Power to the Adept PA-4 Power Chassis” on page 92).



**WARNING:** Electrical hazard!

Changing the voltage setting in the power chassis must be done by a skilled person. The power supply can injure or kill a person who does not perform this procedure correctly.

#### Part 1 – Insulating Power Chassis Power Cord (All Systems)



**WARNING:** High AC voltage is coupled through capacitors to the blue wire of the PA-4 power chassis power cord. If you change the voltage setting from 380-415 VAC to 200-240 VAC, you must add additional insulation to the blue wire according to the directions provided below. Failure to do this could result in injury or death.

1. Make sure the power chassis and controller are turned off. Disconnect the controller and the PA-4 chassis from the AC power source. Verify that power remains off during all parts of this procedure.
2. If a 5-wire plug has already been installed, remove the plug.
3. Locate the two pieces of shrink tubing in the accessory kit; one is 7 mm (1/4-inch) diameter, the other is 19 mm (3/4-inch).
4. Place the 7 mm (1/4-inch) shrink tubing over the end of the blue wire in the power cord and use a heat gun to apply it (see Figure 4-17).
5. Fold the blue wire back (see Figure 4-17).
6. Place the 19 mm (3/4-inch) shrink tubing over the blue wire and the power cord insulation and use a heat gun to apply it (see Figure 4-17).
7. Install a 4-wire plug (or wire directly to an appropriate service disconnect) according to the 200-240VAC section in Table 4-3 on page 93.

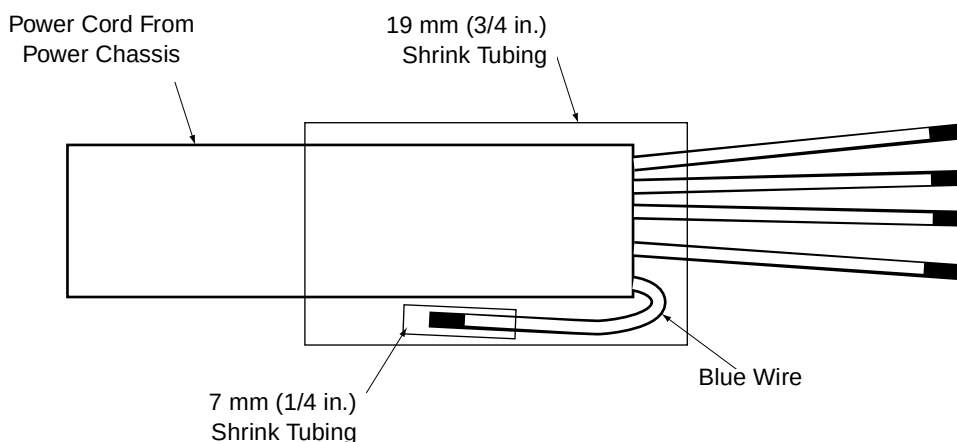


**Figure 4-17. Insulating Blue Wire in Power Cord (200-240VAC)**

### Part 2– Rotating Voltage Selector in Power Chassis

1. Open the front air-intake grill on the power chassis by loosening two screws and swinging the grill out.
2. Inspect the voltage setting; it is marked on the front of the voltage selector plug. To change the voltage setting, remove the selector, rotate it 180 degrees so the required setting is shown, and replace it. See Figure 5-6 on page 101.
3. Close the grill and secure the two screws.
4. Clearly mark or alter the ID label, on the side of the PA-4 chassis, to show the new voltage configuration (see Figure 4-18).

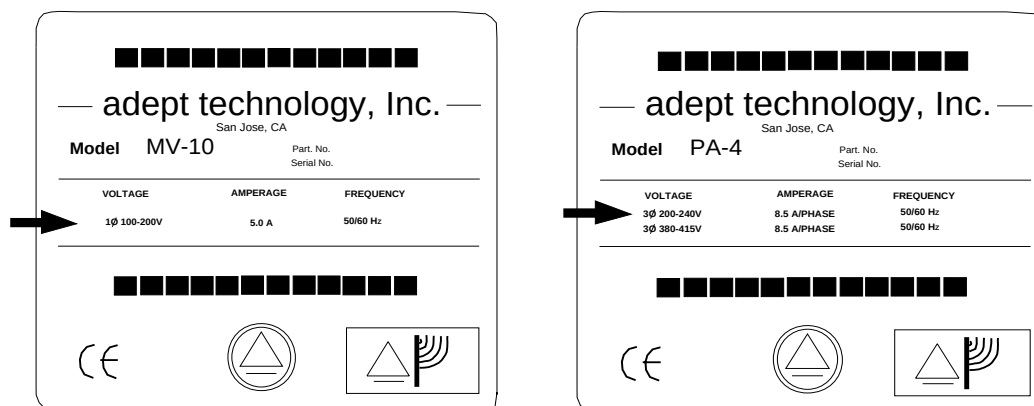


**Figure 4-18. Power Labels**

### Changing From 200-240 VAC to 380-415 VAC

To change the AC voltage setting from 3-phase 200-240VAC to 3-phase 380-415VAC, follow the two-part procedure below. (Also see “Connecting AC Power to the Adept PA-4 Power Chassis” on page 92).

**WARNING:** Electrical hazard!

Changing the voltage setting in the power chassis must be done by a skilled person. The power supply can injure or kill a person who does not perform this procedure correctly.

**Part 1– Rotating Voltage Selector in Power Chassis**

1. Open the front air-intake grill on the power chassis by loosening two screws and swinging the grill out.
2. Inspect the voltage setting; it is marked on the front of the voltage selector plug. To change the voltage setting, remove the selector, rotate it 180 degrees so the required setting is shown, and replace it (see Figure 5-6 on page 101).
3. Close the grill and secure the two screws.
4. Clearly mark or alter the ID label, on the side of the PA-4 power chassis, to show the new voltage configuration (see Figure 4-18 on page 90).

**Part 2– Insulating Power Chassis Power Cord**

**WARNING:** High AC voltage is coupled through capacitors to the blue wire of the PA-4 power chassis power cord. If you change the voltage setting from 200-240 VAC to 380-415VAC, you must add additional insulation to the blue wire according to the directions provided below. Failure to do this could result in injury or death.

1. Make sure the power chassis and controller are turned off. Disconnect the controller and the PA-4 power chassis from the AC power source. Verify that power remains off during all parts of this procedure.
2. If installed, remove the 4-wire plug.
3. Remove and discard the 19 mm (3/4-inch) shrink tubing from the end of the power cord.
4. Remove and discard the 7 mm (1/4-inch) shrink tubing from the end of the blue wire in the power cord (see Figure 4-19 on page 92).
5. Place the 19 mm (3/4-inch) piece of shrink tubing from the accessory kit over the end of the power cord. Use a heat gun to apply the shrink tubing (see Figure 4-19).
6. Install a 5-wire plug (or wire directly to an appropriate service disconnect) according to the 200-240VAC section in Table 4-3 on page 93.

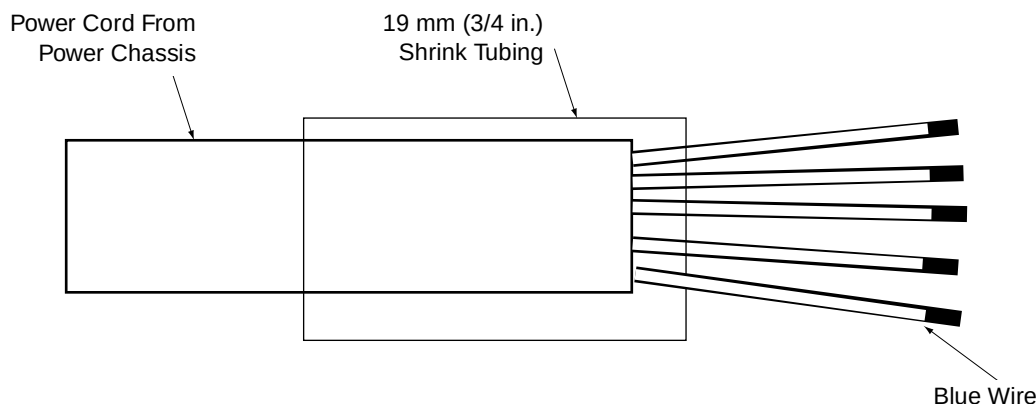


Figure 4-19. Insulating Blue Wire in Power Cord (380-415 VAC)

## 4.10 Connecting AC Power to the Adept PA-4 Power Chassis

For systems without the MMSP option, power is connected directly to the power chassis. For systems with the MMSP option, power is connected through the security panel. The following sections detail connection of a system without the MMSP option. See Chapter 5 for details on installing power to an MMSP equipped system.

The Adept PA-4 power chassis is shipped from the factory configured for either 380-415VAC or 200-240VAC operation, depending on your sales order. A voltage setting label is located on the front of the chassis below the circuit breaker. The voltage setting is also shown on the ID label on the side of the chassis. Verify that the setting matches your facility power before installation. This chassis is designed for 3-phase operation only.

If you need to change the AC voltage setting from 380-415VAC to 200-240VAC, see section 4.9.



### **WARNING:** Electrical hazard!

Verify the voltage settings are correct before turning on power. Operating the Adept PA-4 power chassis with incorrect voltage settings can cause damage or injury.

### Connecting the Power Chassis AC Power Cord to AC Supply (Non-MMSP System)

The user end of the cord is unterminated. Connect each conductor of the power cord securely to your AC power source, using the color code shown in Table 4-3. The installation must meet all applicable European, international, and national standards and regulations.

**Table 4-3. AC Power Cord Specifications for Power Chassis**

|                                                                                          |                                                                                         |
|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Cord length                                                                              | 3 meters $\pm 0.1$ m (9 ft. 10 in. $\pm 4$ in.)                                         |
| Cord rating                                                                              | 25 amps                                                                                 |
| Number and size of conductor size                                                        | 5 x 2.5 mm <sup>2</sup>                                                                 |
| Color code: 380 - 415VAC<br>line 1<br>line 2<br>line 3<br>neutral<br>ground              | black<br>black<br>brown<br>blue<br>green/yellow                                         |
| Color code: 200 - 240VAC<br>line 1<br>line 2<br>line 3<br><b>no connection</b><br>ground | black<br>black<br>brown<br><b>blue</b> (must be insulated; see page 89)<br>green/yellow |

**WARNING:** Electrical hazard!

The installation of the power cord must be done by a skilled person. The power supply can injure or kill the person who installs the cord. An incorrect installation can injure or kill anyone that touches the equipment in the robot workcell.

The protective ground conductor (colored green/yellow) of the Adept PA-4 power chassis is internally connected to the accessible metal parts of the power chassis. To ensure electrical-shock protection, this must be connected to a properly grounded power source.



**WARNING:** Ensure that a proper protective ground connection exists before turning on the power. The Adept PA-4 power chassis and the Adept MV controller must be connected to the same earth ground.

## 4.11 Grounding the Adept Robot System

Proper grounding is essential for safe and reliable robot operation. Follow these recommendations to properly ground your robot system.

### Adept Robot Grounding

The major structural parts of the robot are connected to the ground point on the base of the robot (see Figure 4-20). The user must install a ground wire to the robot. Make sure to remove all paint from the surface under the screw at the ground point and use a star washer to ensure a proper ground connection.

## Robot-Mounted Equipment Grounding

The following parts of an Adept-XL robot are not grounded to protective earth: the joint 3 quill, the tool flange, and all access covers. If hazardous voltages are present at any user-supplied robot-mounted equipment or tooling, you must install a ground connection from that equipment/tooling to the ground point on the robot base. Hazardous voltages can be considered anything in excess of 30VAC (42.4VAC peak) or 60VDC.

See also Figure 11-6 on page 247 for the grounding point on the tool flange.



**WARNING:** Failing to ground robot-mounted equipment or tooling that uses hazardous voltages could lead to injury or death of a person touching the end-effector when an electrical fault condition exists.

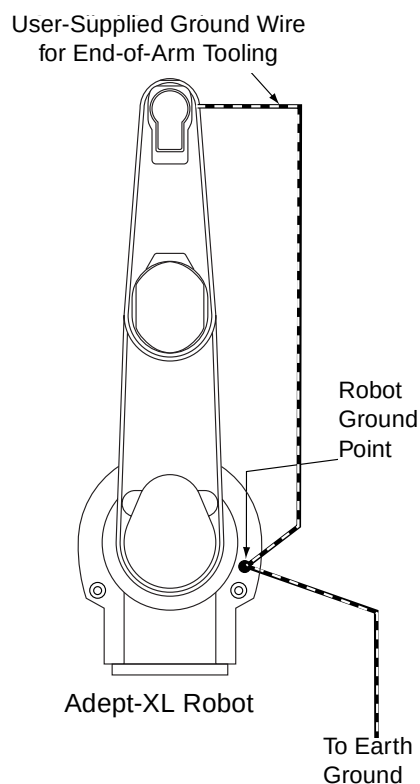


Figure 4-20. Adept-XL Robot Ground Point

# MMSP Installation and Configuration

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# 5

The emergency stop system of the Manual Mode Safety Package (MMSP) has several interconnected components (see Figure 5-1). The Security Panel controls the Category 3 E-Stop system. It works together with the AUTO/MANUAL operating mode key switch on the CIP.

## 5.1 Installation of the MMSP Option

---

Before beginning this installation, you should have completed all the steps in Chapter 3 and the steps in Chapter 4 through section 4.7.

Adept recommends mounting the Security Panel in the same enclosure as the Adept MV controller, or in a separate, protected enclosure that fulfills the requirements detailed in Table 2-2 on page 47. See Figure 11-10 on page 251 for the dimensions of Security Panel.

Figure 5-2 shows the Security Panel and its associated components. On the left side of the Control Rail (X1) is the Category 3 E-Stop board with the terminals for the connections of customer-supplied safety equipment and digital I/O signals. On the right side is the Teach Restrict Interface (TRI) Board. The lower DIN rail is the Power Rail (X2) containing the external 24VDC power supply, the contactors, and the circuit breaker for the power chassis.

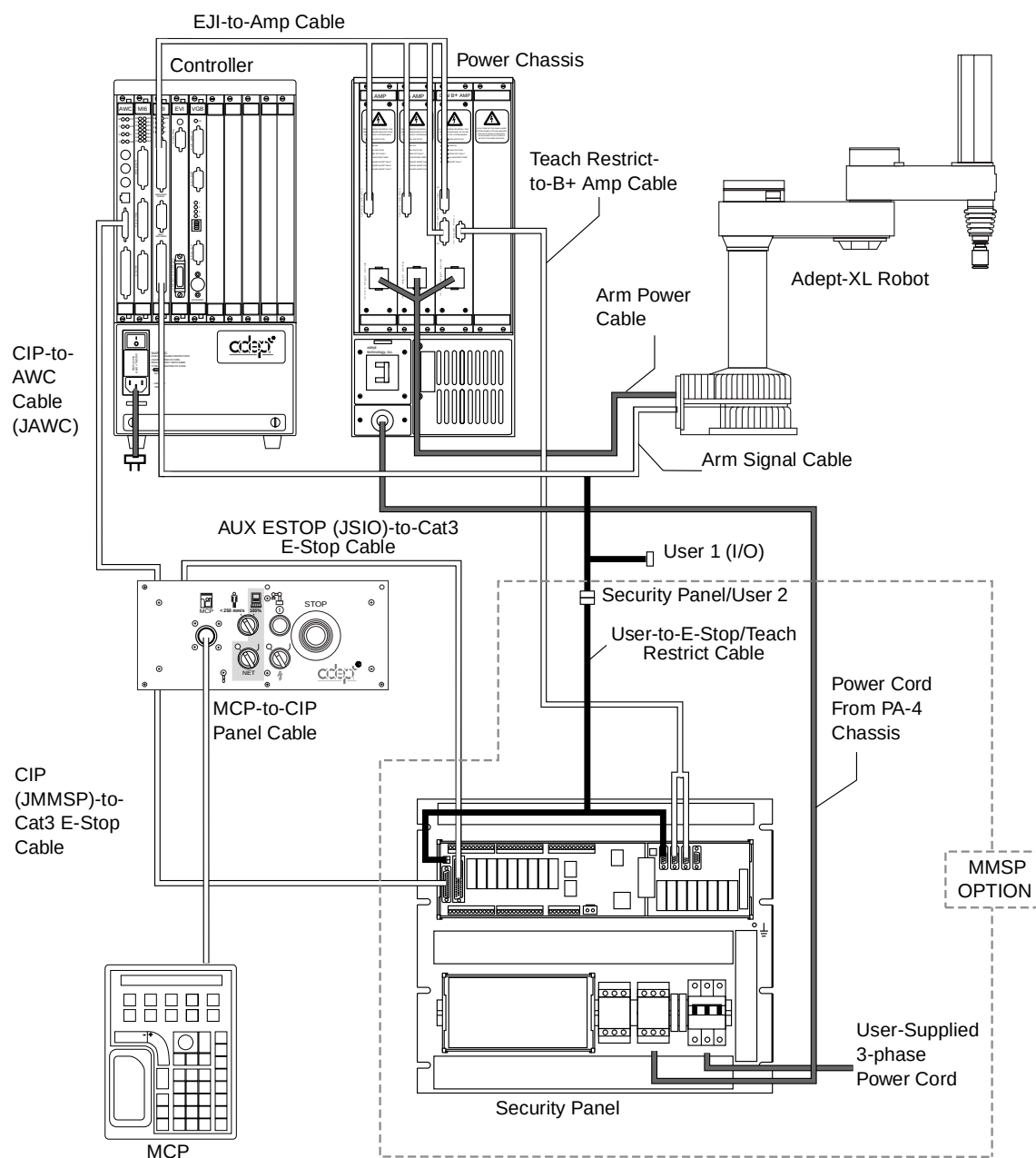


Figure 5-1. Components of a Category 3 E-Stop System

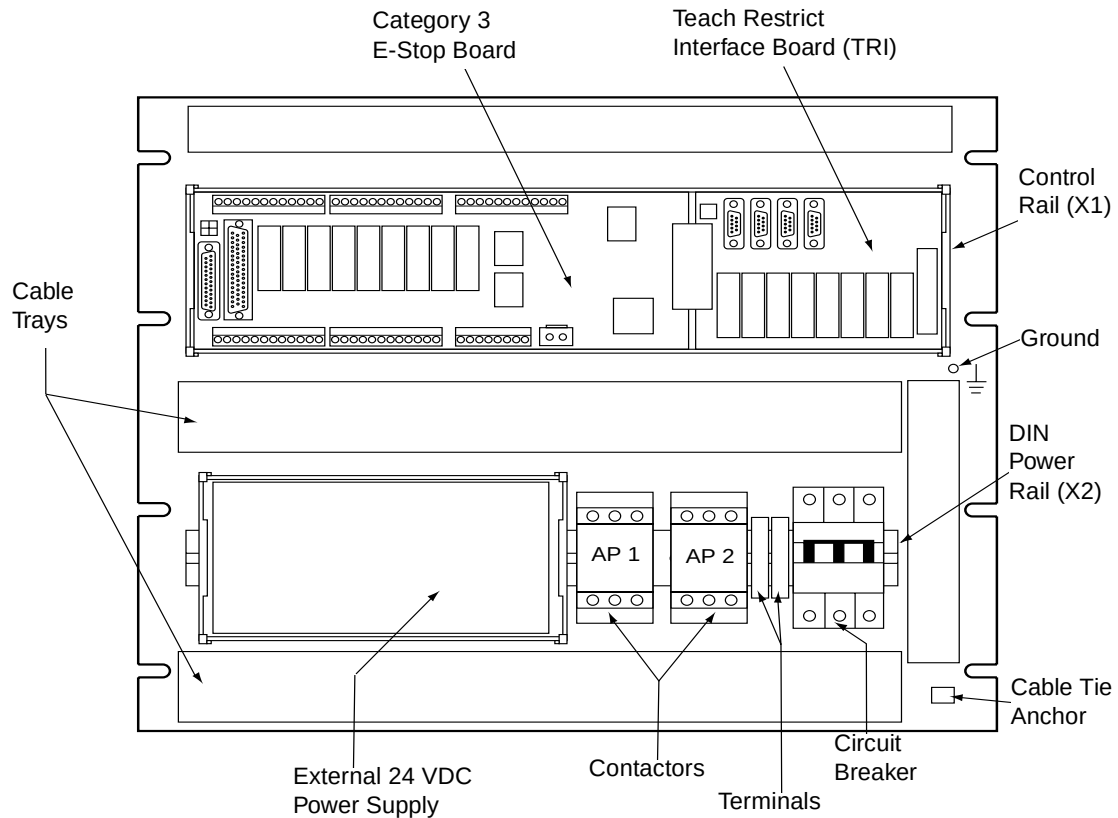


**Figure 5-2. Security Panel**

## Connecting the Security Panel to the CIP

Communication between the external CIP and the Security Panel is through two cables: the CIP-to-Cat3 E-Stop cable and the JSIO-to-Cat3 E-Stop cable.

Installation procedure for the CIP-to-Cat3 E-Stop Cable (see Figure 5-1):

1. Turn the Adept MV controller off.
2. Connect the male plug of the CIP-to-Cat3 E-Stop cable to the connector J3 on the Category 3 Emergency Stop board. (See Figure 5-3 on page 98.) Tighten the two captive screws securely. Connect the female connector of the cable to the connector JMMSP on the CIP. Tighten the two captive screws securely.
3. Connect the 50-pin male end of the JSIO-to-Cat3 E-Stop cable to the JSIO connector on the CIP. Connect the other end to J2 on the Category 3 E-Stop board.

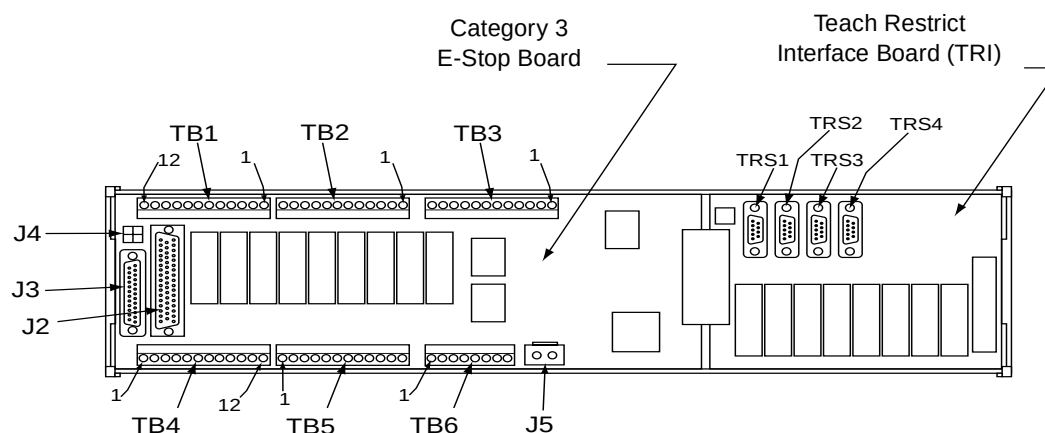


Figure 5-3. Connectors on the Control Rail

## Connecting the Security Panel to the Adept Robot

For speed limiting of joints 1 and 2 in Manual mode, the User-to-E-Stop/Teach Restrict cable must be installed between the “Security Panel/User 2” connector on the Arm Signal cable, the E-Stop board, and the Teach Restrict Interface board. The robot cannot be operated in Manual mode until this connection is made.

Installation procedure for the User-to-E-Stop/Teach Restrict cable (see Figure 5-1 and Figure 5-3):

1. Turn off the PA-4 power chassis and Adept MV controller.
2. Remove the brake release jumper (if installed) from the “Security Panel/User 2” connector on the robot Arm Signal cable.
3. Plug the 15-pin female connector, marked “Security Panel/User 2” of the User-to-E-Stop/Teach Restrict cable to the “Security Panel/User 2” connector on the robot Arm Signal cable. Tighten the two captive screws securely.
4. Connect the 9-pin, D-Sub male plug, labeled TRS1 to the D-Sub connector TRS1 on the Teach Restrict Interface board. Tighten the two captive screws securely.
5. Connect the square plug to the square connector J4 on the E-Stop Board.



**CAUTION:** Verify that all components are fully inserted and screwed down.

## Connecting the Security Panel to the Adept PA-4 Power Chassis

For speed limiting of joints 3 and 4 in Manual mode, the Teach Restrict-to-B+ Amp cable must be installed between the Adept PA-4 power chassis and the Teach Restrict Interface board on the control rail.

Installation procedure for the Teach Restrict-to-B+ Amp cable (see Figure 5-1 and Figure 5-3):

1. Turn off the PA-4 power chassis and Adept MV controller.

2. Plug the 15-pin, high-density, D-Sub male connector of the Teach Restrict-to-B+ Amp cable into the Teach Restrict socket on the B+ Amplifier board in the power chassis. Tighten the two captive screws securely.
3. Plug the 9-pin, D-Sub connector labeled TRS2 into the socket TRS2 on the Teach Restrict Interface board. Tighten the two captive screws securely.
4. Plug the 9-pin, D-Sub connector labeled TRS3 into the socket TRS3 on the Teach Restrict Interface board. Tighten the two captive screws securely.

## Changing the Voltage Setting for the Power Chassis (From 380-415 VAC to 200-240 VAC)

To change the AC voltage setting from 3-phase 380-415VAC to 3-phase 200-240VAC, follow the three-part procedure below. This procedure must be completed before installing the power chassis. (Also see “Connecting AC Power to the Adept PA-4 Power Chassis” on page 105).



### **WARNING:** Electrical hazard!

Changing the voltage setting in the power chassis must be done by a skilled person. The power supply can injure or kill a person who does not perform this procedure correctly.

### Part 1 – Insulating Power Chassis Power Cord



**WARNING:** High AC voltage is coupled through capacitors to the blue wire of the PA-4 power chassis power cord. If you change the voltage setting from 380-415VAC to 200-240VAC, you must add additional insulation to the blue wire according to the directions provided below. Failure to do this could result in injury or death.

1. Turn off the power chassis and controller. Disconnect the controller and the Security Panel from the AC power source. Verify that power remains off during all parts of this procedure.
2. Disconnect the 5-wire power chassis power cord at the power source from the AP2.T1,T2,T3, neutral, and protective earth terminals on the Security Panel.
3. Locate the two pieces of shrink tubing in the accessory kit; one is 7 mm (1/4-inch) diameter, the other is 19 mm (3/4-inch).
4. Place the 7 mm (1/4-inch) shrink tubing over the end of the blue wire in the power cord and use a heat gun to apply it (see Figure 5-4).
5. Fold the blue wire back.
6. Place the 19 mm (3/4-inch) shrink tubing over the end of the blue wire and the power cord insulation. Use a heat gun to apply it (see Figure 5-4).
7. Reinstall the power chassis power cord at the Security Panel according to the 200-240VAC section in Table 5-11 on page 106 (also see Figure 5-1 on page 96).

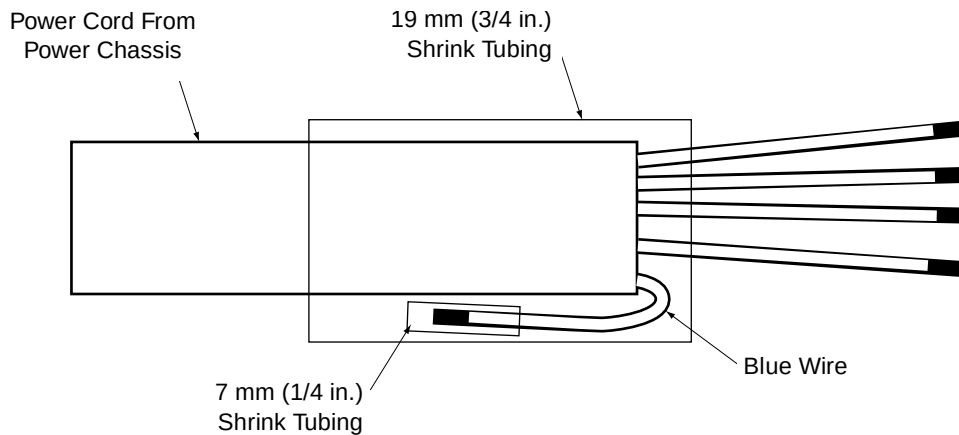


**Figure 5-4. Insulating Blue Wire in Power Cord (200-240 VAC)**

### **Part 2 – Rotating Voltage Selector in Power Chassis**

1. Open the front air-intake grill on the power chassis by loosening two screws and swinging the grill out.
2. Inspect the voltage setting; it is marked on the front of the voltage selector plug. To change the voltage setting, remove the selector, rotate it 180 degrees so the required setting is shown, and replace it (see Figure 5-6 on page 101).
3. Close the grill and secure the two screws.
4. Clearly mark or alter the ID label on the side of the PA-4 power chassis to show the new voltage configuration.
5. Clearly mark or alter the ID label on the side of the Security Panel to show the new voltage configuration (see Figure 5-7 on page 102).
6. Clearly mark or paste an alternative label over the existing label below the circuit breaker (on the front of the chassis) to show the new voltage configuration.
7. Reconnect the controller and Security Panel to the AC power source.

### **Part 3 – Moving Blue Wire on Security Panel**

1. Locate the blue wire labeled “**Neutral**” that is installed on the neutral terminal on the Power Rail (X2:N).
2. Remove that wire from the neutral terminal and install it in the L2 position on contactor AP1 (X2:AP1.L2), next to the wire that is already installed there. See Figure 5-5 on page 101.

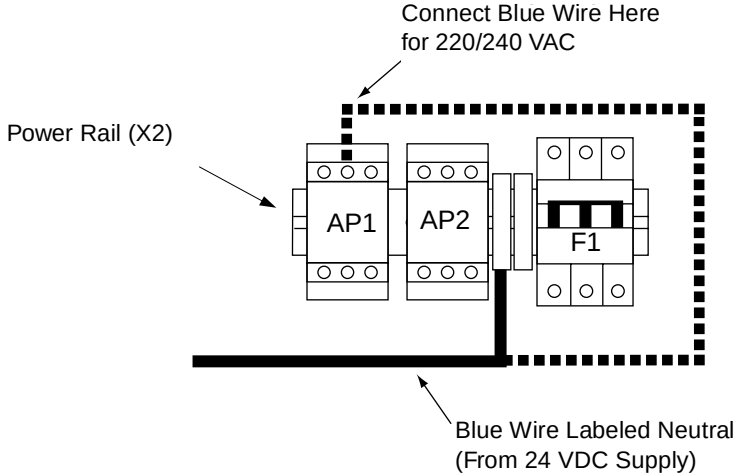


Figure 5-5. Moving Blue Wire From Neutral to AP1.L2 (200-240 VAC)

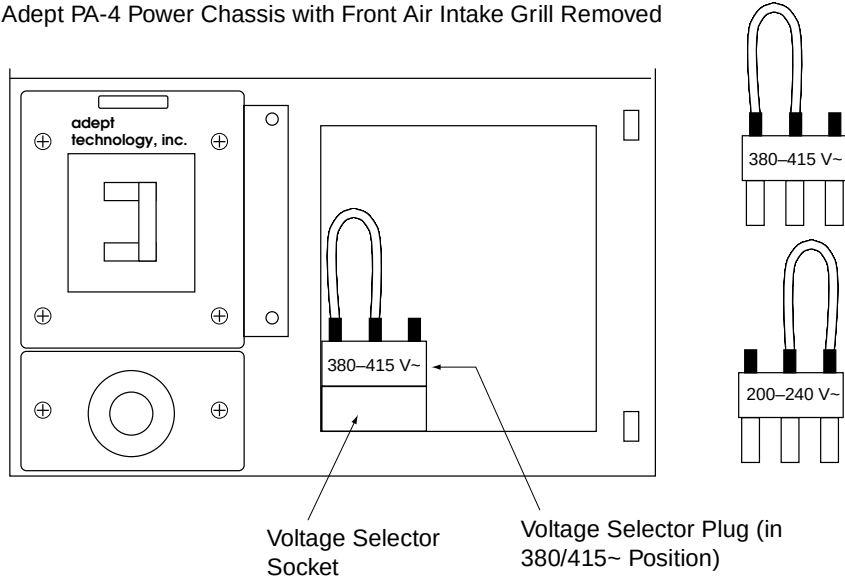


Figure 5-6. Changing Voltage in Power Chassis

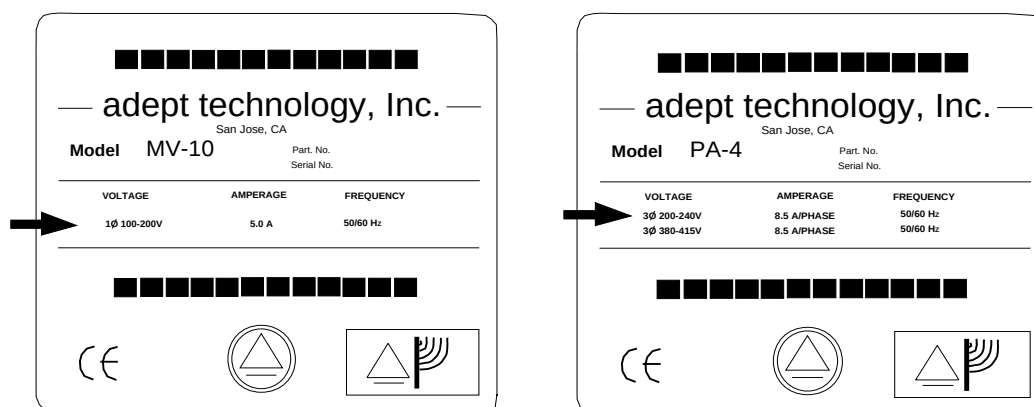


Figure 5-7. Location of Power Labels

### Changing the Voltage Setting for the Power Chassis (From 200-240VAC to 380-415VAC)

To change the AC voltage setting from 3-phase 200-240 VAC to 3-phase 380-415 VAC, follow the three-part procedure below. This procedure must be performed by a skilled person and should be completed before installing the power chassis. (Also see “Connecting AC Power to the Adept PA-4 Power Chassis” on page 105).



**WARNING:** Electrical hazard!

Changing the voltage setting in the power chassis must be done by a skilled person. The power supply can injure or kill a person who does not perform this procedure correctly.

#### Part 1– Moving Blue Wire on Security Panel

1. Locate the blue wire labeled “**Neutral**” that is installed on the L2 position on contactor AP1 (X2:AP1.L2).
2. Remove that wire from the L2 position on contactor AP1 (X2:AP1.L2) and install it in the neutral terminal on the Power Rail (X2:N). See Figure 5-8 on page 103.

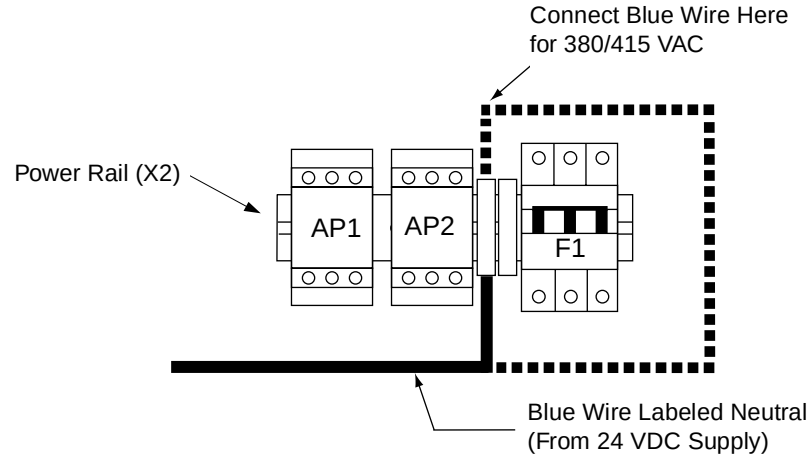


**Figure 5-8. Moving Blue Wire From AP1.L2 to Neutral (380-415 VAC)**

### Part 2 – Rotating Voltage Selector in Power Chassis

1. Open the front air-intake grill on the power chassis by loosening two screws and swinging the grill out.
2. Inspect the voltage setting; it is marked on the front of the voltage selector plug. To change the voltage setting, remove the selector, rotate it 180 degrees so the required setting is shown, and replace it (see Figure 5-6 on page 101).
3. Close the grill and secure the two screws.
4. Clearly mark or alter the ID label on the side of the PA-4 power chassis to show the new voltage configuration (see Figure 5-7 on page 102).
5. Clearly mark or alter the ID label on the side of the Security Panel to show the new voltage configuration.
6. Clearly mark or paste an alternative label over the existing label below the circuit breaker (on the front of the chassis) to show the new voltage configuration.
7. Reconnect the controller and Security Panel to the AC power source.

### Part 3 – Insulating Power Chassis Power Cord (All Systems)



**WARNING:** High AC voltage is coupled through capacitors to the blue wire of the PA-4 power chassis power cord. If you change the voltage setting from 200-240 VAC to 380-415 VAC, you must add additional insulation to the blue wire according to the directions provided below. Failure to do this could result in injury or death.

1. Turn off the power chassis and controller. Disconnect the controller and the optional Security Panel from the AC power source. Verify that power remains off during all parts of this procedure.
2. Remove and discard the 19 mm (3/4-inch) shrink tubing from the end of the power cord.
3. Remove and discard the 7 mm (1/4-inch) shrink tubing from the end of the blue wire in the power cord (see Figure 5-9 on page 104).

4. Locate the 19 mm (3/4-inch) piece of shrink tubing in the accessory kit.
5. Place the 19 mm (3/4-inch) piece of shrink tubing from the accessory kit over the end of the power cord. Use a heat gun to apply the shrink tubing.
6. Reconnect the 5-wire power chassis power cord at the power source from the AP2.T1,T2,T3, neutral, and protective earth terminals on the Security Panel.
7. Reinstall the power chassis power cord at the Security Panel according to the 380-415 VAC section in Figure 5-10 on page 106 (also see Figure 5-1 on page 96).

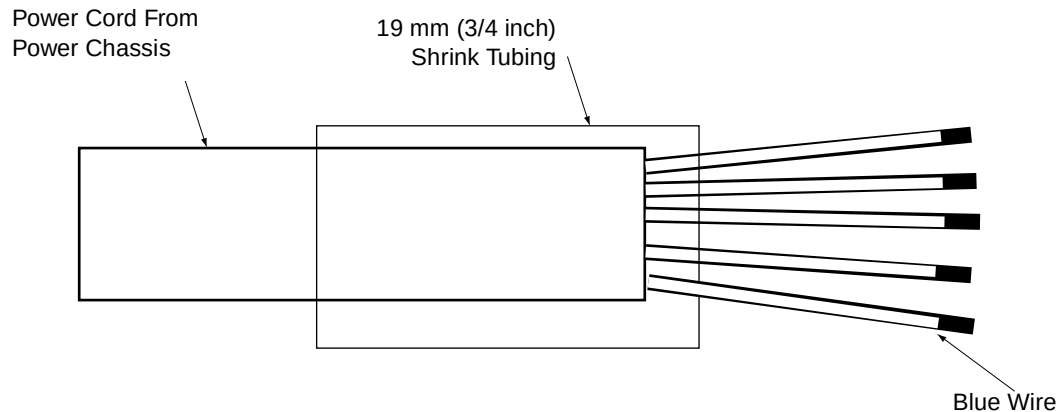


**Figure 5-9. Insulating Blue Wire in Power Cord (380-415 VAC)**

## Connecting AC Power to the Adept PA-4 Power Chassis

The Adept PA-4 power chassis provides amplified power signals to drive the robot motors in an Adept robot system. The amplifier modules in the Adept PA-4 power chassis receive control signals from the Adept MV controller. The amplifier modules then provide the necessary current to drive the various robot joint motors.

The facility AC power supply must conform to the requirements detailed in “Power Requirements” on page 48.

If you need to change the AC voltage setting from 380-415 VAC to 200-240 VAC, see page 99.



**WARNING:** Electrical hazard!

Verify that the voltage settings are correct before turning on power. Operating the Adept PA-4 power chassis with incorrect voltage settings can cause damage or injury.



**WARNING:** Electrical hazard!

Voltage regulations in Europe have changed from 220V single phase to 230V. The result is that the 3-phase voltage is now  $400V = \sqrt{3} * 230V$ . It is absolutely *not* possible to use 3-phase 380V power *without* a neutral on an Adept robot equipped with the MMSP. The neutral is mandatory to run the PA-4 power chassis with 3-phase 380V. In the case of 3-phase 380V, we rectify only the 220V between two lines and neutral, which results in 220V input voltage for the rectifier of the amplifiers. If you use a line instead of the neutral in the 3-phase 380V configuration, that will immediately destroy the PA-4 power chassis. The only way to use 3-phase 380V without a neutral is to add a step-down transformer to bring the voltages down to 3-phase 220V. In that case it is also necessary to switch the configuration of the PA-4 power chassis to 3-phase 220V.

**IMPORTANT:** You must also change the wiring of the 24V power supply on the mounting panel of the MMSP when changing the voltage configuration of the PA-4 power chassis. The voltages in Europe have changed and there is no longer single phase 220V power, it is now 3-phase 230V. The result is that the 3-phase voltage is now  $400V = \sqrt{3} * 230V$ .

### Typical AC Power Installation Diagrams

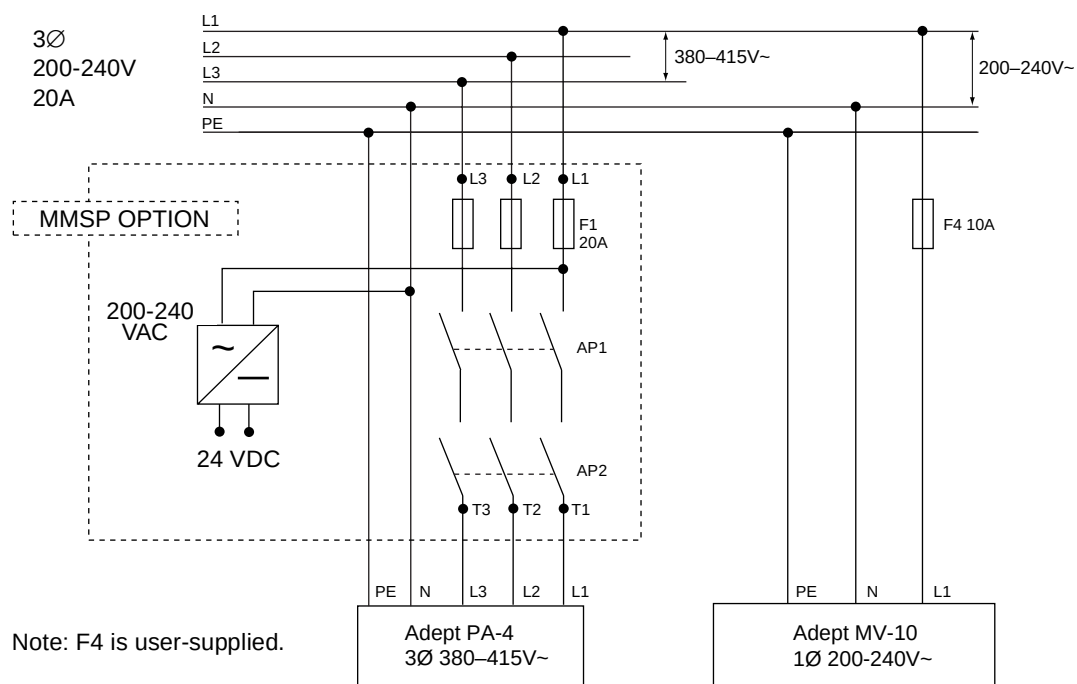


Figure 5-10. Typical 380-415 VAC Connection for MMSP System

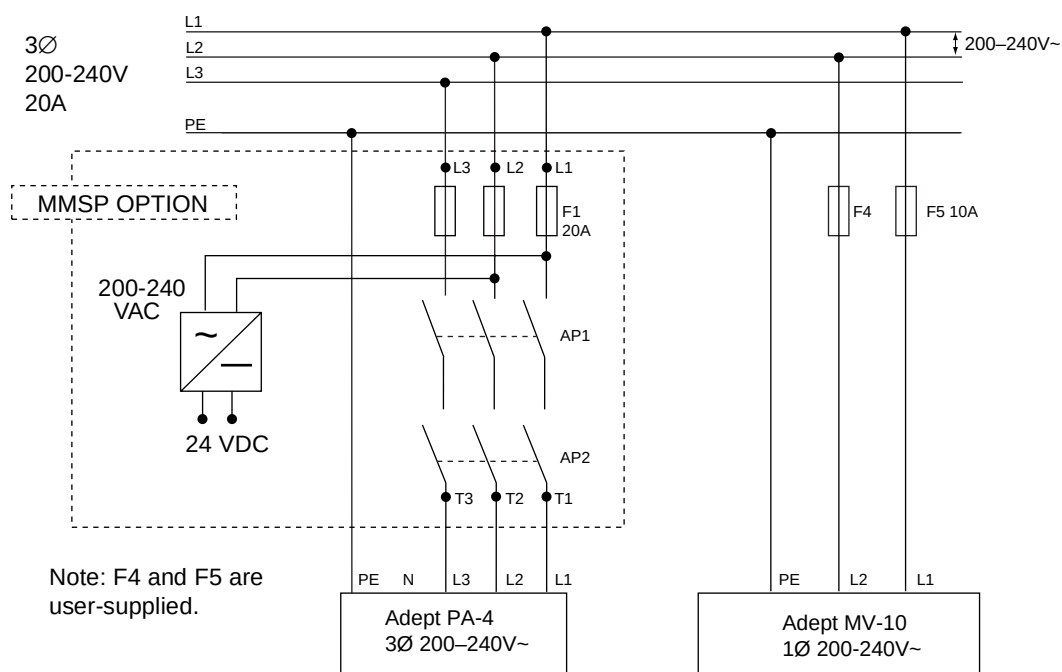


Figure 5-11. Typical 3-Phase 200-240 VAC Connection for MMSP System

### Connecting Power Cord of Power Chassis to Security Panel



**WARNING:** Electrical hazard!

The installation of the power cord must be done by a skilled person. The power supply can injure or kill the person who installs the cord. An incorrect installation can injure or kill anybody who touches the equipment in the robot workcell.



**WARNING:** The 3-phase AC power cord of the PA-4 power chassis **must** be installed at the contacts on the Power Rail (X2). This ensures that the MMSP can remove power from the power chassis when rewired. Failure to do this prevents safe operation and could permit injury or death.

The user end of the cord is unterminated. Connect each conductor of the power cord securely to the contacts of the contactor AP2 and terminals for protective ground and the neutral. See Table 2-4 on page 49 for the information on terminal numbers and color code for the connections. The installation must meet all applicable local and national standards and regulations.

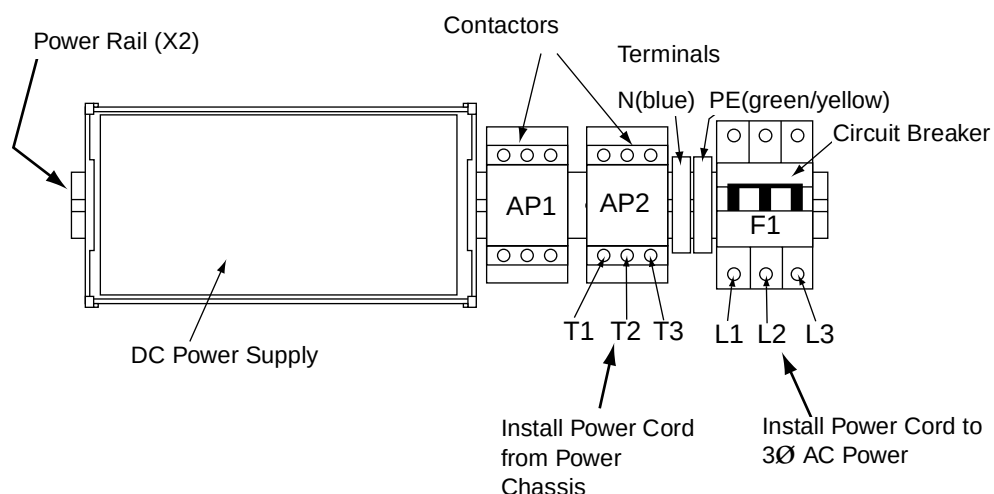
**NOTE:** In 380-415V installations, a “5-wire” installation (3-line + neutral + PE) is required. In 200-240V installation, a “4-wire” installation (no neutral) is required. The blue wire from the PA-4 power chassis must be insulated (see Figure 5-4 on page 100).

**Table 5-1. AC Power Cord Specifications for Power Chassis**

|                                                                                           |                                                                                         |
|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Cord length                                                                               | 3 meters $\pm 0.1$ m (9 ft. 10 in. $\pm 4$ in.)                                         |
| Cord rating                                                                               | 25 amps                                                                                 |
| Number and size of conductor size                                                         | 5 x 2.5 mm <sup>2</sup>                                                                 |
| Color code: 380 - 415 VAC<br>line 1<br>line 2<br>line 3<br>neutral<br>ground              | black<br>black<br>brown<br>blue<br>green/yellow                                         |
| Color code: 200 - 240 VAC<br>line 1<br>line 2<br>line 3<br><b>no connection</b><br>ground | black<br>black<br>brown<br><b>blue</b> (must be insulated; see page 99)<br>green/yellow |

**Table 5-2. Connecting Power Cord of the Power Chassis to the Terminals on the Power Rail (X2)**

| Wire/Description             | Wire Color                                      | Terminal Number |
|------------------------------|-------------------------------------------------|-----------------|
| Color code: 3Ø, 380 - 415VAC |                                                 |                 |
| line 1                       | black                                           | X2:AP2.T1       |
| line 2                       | black                                           | X2:AP2.T2       |
| line 3                       | brown                                           | X2:AP2.T3       |
| neutral                      | blue                                            | X2:N            |
| ground                       | green/yellow                                    | X2:PE           |
| Color code: 3Ø, 200 - 240VAC |                                                 |                 |
| line 1                       | black                                           | X2:AP2.T1       |
| line 2                       | black                                           | X2:AP2.T2       |
| line 3                       | brown                                           | X2:AP2.T3       |
| <b>no connection</b>         | <b>blue</b> (must be insulated;<br>see page 99) | –               |
| ground                       | green/yellow                                    | X2:PE           |

**Figure 5-12. Connectors on Power Rail**

## AC Power Requirements for MMSP Option

The AC power for the power chassis is routed through the security panel. See “Power Requirements” on page 48 for power requirements. The power consumed by the security panel itself is negligible and is included in the 20 amp circuit requirement.

## Connecting AC Power to the Security Panel

The main AC power supply for the robot is connected to the circuit breaker F1 on the Power Rail (X2). The 3-phase AC power cord must be supplied by the user. The current rating should equal or exceed that specified in Table 5-3. The cord must meet all applicable local, national, and international standards and regulations for current/voltage ratings, wire gauge, colors, etc.

Connect each conductor of the power cord securely to your AC power source; refer to the first two columns of Table 5-4 for the color code. Install the other end of the power cord to the terminals shown in the terminal number column. The installation must meet all applicable local, national, and international standards and regulations.



**WARNING:** Electrical hazard!

The installation of the power cord must be done by a skilled person. The power supply can injure or kill the person who installs the cord. An incorrect installation can injure or kill anybody who touches the equipment in the robot workcell.

**Table 5-3. Customer-Supplied AC Power Cord Specifications for Security Panel**

|                               |                                                                                    |
|-------------------------------|------------------------------------------------------------------------------------|
| Cord rating                   | 25 amps                                                                            |
| Number and size of conductors | 380 - 415 VAC = 5 x 2.5 mm <sup>2</sup><br>200 - 240 VAC = 4 x 2.5 mm <sup>2</sup> |

**Table 5-4. Connection of Main AC Power Cord to the Circuit Breaker on the Power Rail (X2)**

| Wire/Description             | Wire Color   | Terminal Number |
|------------------------------|--------------|-----------------|
| Color code: 3Ø, 380 - 415VAC |              |                 |
| line 1                       | black        | X2:F1.L1        |
| line 2                       | black        | X2:F1.L2        |
| line 3                       | brown        | X2:F1.L3        |
| neutral                      | blue         | X2.N            |
| ground                       | green/yellow | X2.PE           |
| Color code: 3Ø, 200 - 240VAC |              |                 |
| line 1                       | black        | X2:F1.L1        |
| line 2                       | black        | X2:F1.L2        |
| line 3                       | brown        | X2:F1.L3        |
| ground                       | green/yellow | X2.PE           |

## Grounding an MMSP Equipped System

The Security Panel must be grounded using the M5 lug on the right side of the panel; see Figure 5-1 and Figure 5-2. The ground wire should be as short as possible. Typically it would be grounded to the frame of the equipment cabinet.

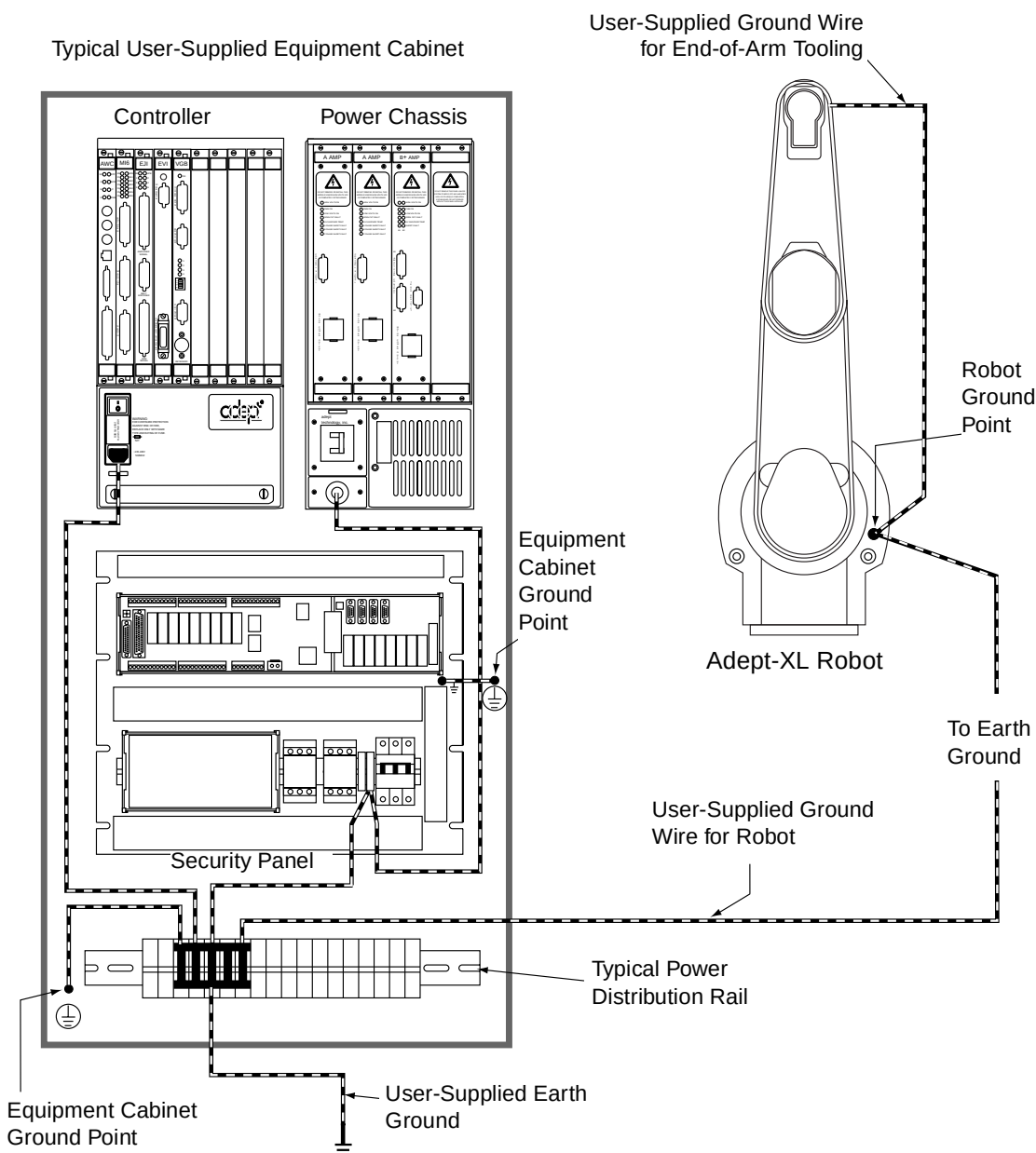


Figure 5-13. Adept-XL Robot System Grounding Diagram

## 5.2 Security Panel Functions

The Security Panel:

- Checks for faults in the safety system prior to power-up in Manual mode (cyclic checking)
- Removes power from the robot if the Teach Restrict sensors in the robot and power chassis detect excessive speed and/or acceleration while the robot is in Manual mode
- Interlocks with the Category B safety circuitry in the Adept MV controller<sup>1</sup>
- Indicates to the Adept MV controller the source of emergency stop conditions

The emergency stop circuitry has two independent channels and is constructed so that *no single failure* can cause a loss of the safety function and that any latent failures can be detected before power is applied – the definition of Category 3 operation.

Redundant connections are provided on the Security Panel for customer E-Stop safety barriers. See “Category 3 Emergency Stop Circuitry” on page 117. If one of these switches or contacts is open, High Power will be turned off. The Security Panel also supplies voltage-free contacts that are closed when High Power is on and open when High Power is off. These contacts can be used to switch additional equipment depending on the status of the emergency stop circuit.

The Security Panel also supplies voltage-free contacts to signal that the robot is in Manual mode. These contacts can be used by the customer to disconnect input devices or other external peripherals (turntables, conveyors, etc.)

### Description of “Mute” Capability

There are two pairs of terminals (see Table 5-5) on the Security Panel for customer safety barriers that can be muted in Manual mode. Input to these terminals from a safety barrier is muted (not active) in Manual mode, but the input is active in Automatic mode. That means that an interlock switch on a workcell access door can be connected to these terminals and the door can be left open in Manual mode. This is useful for a person who is teaching points in the workcell during program development.

There is a second pair of terminals for a second barrier. This pair of inputs is always active, even in Manual mode. This feature can be used for an inner barrier, safety mat, or light curtain.

These two safety gate circuits can be wired to the CIP or to the E-Stop board on the security panel. See Table 5-5 on page 114 and Table 5-5 on page 114 for details on wiring to the E-Stop board on the security panel. See the *Adept MV Controller User’s Guide* for details on wiring the safety gate feature to the CIP.

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<sup>1</sup> Per EN954, Category B refers to a component that meets the requirements of its environment (voltage, current, temperature). Such components are not necessarily fault-tolerant.

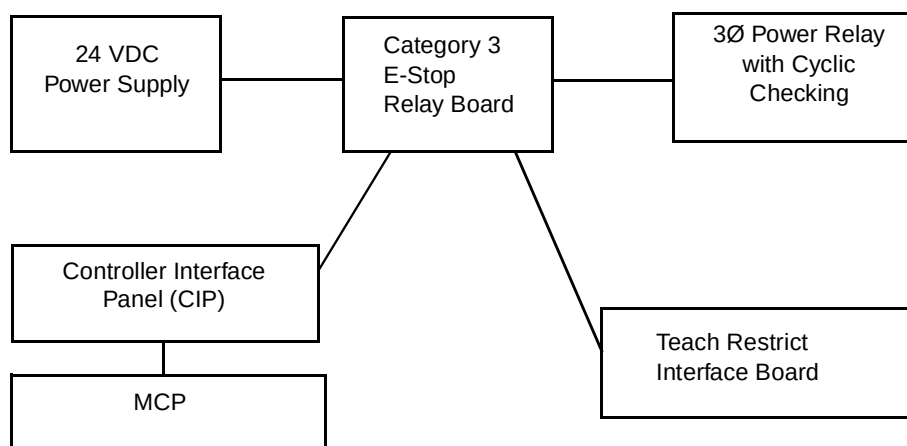


Figure 5-14. Main Components of the Safety System

## Operating in Manual Mode

The most important function of the Security Panel is to protect the operator in Manual mode. To work in Manual mode, the operator switches the lower key switch on the CIP to the “O” position and the operating mode key switch (upper switch) to the MANUAL position. Then the operator gives the instruction to enable High Power, either through an ENABLE POWER monitor command, or by pressing the COMP/PWR button on the MCP. The system starts the process to enable High Power. The sequence to enable High Power in Manual mode is as follows (takes about 20-25 seconds).

1. The system checks all E-Stops (including customer non-mute safety barrier).
2. The operator must release and then close and hold the MCP Enable switch.
3. The system tests the Teach Restrict sensors in the robot and power chassis (cyclic checking).
4. The CIP High Power push button/lamp starts blinking.

**NOTE:** The system waits until the High Power push button/lamp is pressed. If the button has not been pressed in a user-configurable time, the system does not enable High Power and returns an error message.

5. The operator must press the CIP High Power push button/lamp.
6. The contactors close on the Security Panel and the power chassis amplifiers to supply High Power to the robot motors.

While in Manual mode, the robot speed is limited to 250 mm per second (10 inches per second). The motors also run at reduced torque. This is to protect a person who is in the workcell teaching points with the MCP during program development. It is important to remember that the robot speed is **not** limited when the robot is in Automatic mode.

### 5.3 Category 3 Emergency Stop and Teach Restrict Equipment

Systems equipped with the MMSP option have two methods of installing emergency stop circuitry. The first method is to use the JUSER connector on the CIP. This method is detailed in Chapter 8. The second method is to use the TB4 and TB5 connectors on the security panel (see Figure 5-15). Both methods will yield functionally equal results as the state of the circuit on the Security Panel is forwarded to the CIP circuit (see item 11 on Figure 5-16). Wiring to the TB4 and TB5 connectors is mechanically simpler, and two additional sets of contacts for customer safety barriers are provided. Wiring to the CIP is covered in Chapter 8. Wiring to the TB4 and TB5 connectors on the security panel is covered in the following sections.

The Category 3 emergency stop and teach restrict equipment is located on the Control Rail on the Security Panel. Figure 5-15 shows the Category 3 E-Stop board and the Teach Restrict Interface (TRI) board.

**NOTE:** Removable terminal block connectors for TB1 to TB5 on the Category 3 Emergency Stop board are supplied in the accessory kit. Use these connectors to install customer wiring. Adept recommends using crimp-on ferrules on all wires that are installed into terminal blocks.

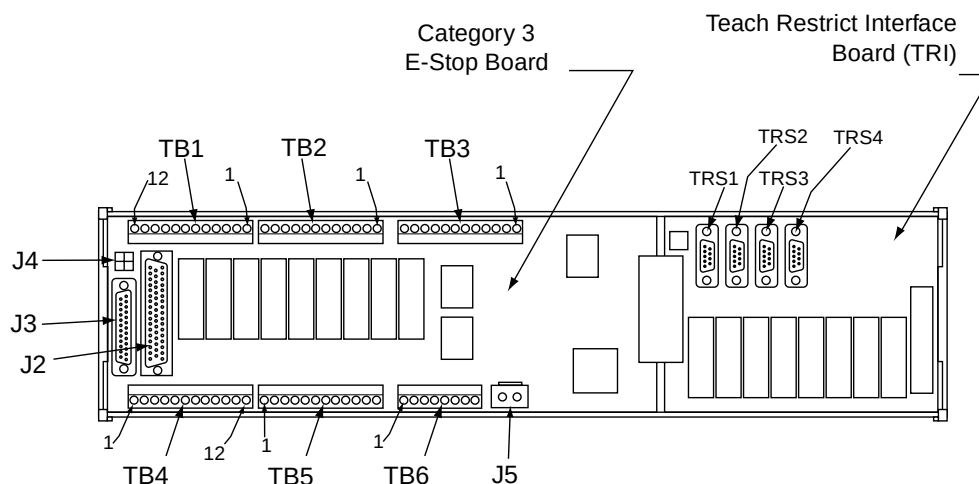


**Figure 5-15. Category 3 E-Stop Board and Teach Restrict Interface (TRI) Board on Control Rail**

The Control Rail contains the terminals for customer-supplied safety equipment. The terminal blocks TB4 and TB5 are for customer E-Stop connections. The terminal block TB4 supplies the terminals for three additional user-supplied E-Stops. These switches are two-pole switches that are normally closed (N/C). The switches must comply with the safety requirements of all European and national standards. If the switches do not comply, the whole installation will not provide sufficient safety for Category 3.



**WARNING:** Do not use switches in the E-Stop circuit that do not comply with Category 3 requirements.

The specifications for user-supplied E-Stop and safety barrier switches are:

- Two-pole (redundant) contacts, positive drive, per EN 60204:1992, Section 10.7.3
- Minimum switching power 24 VA (volt amps)
- Minimum switching voltage 24 VDC
- Minimum switching current 1.0 A DC

The terminals for the user-supplied E-Stop, safety barrier switches, and the names of the connectors and signals are given in Table 5-5.

## Terminal Assignments for Customer E-Stops

The table below gives the terminal assignments of the terminal block TB4 on the Control Rail of the Security Panel. All contacts must be closed to enable High Power. Make sure that sufficient E-Stop switches are provided in the workcell, so they can be easily reached in an emergency.

Install a removable terminal block connector (supplied in the accessory kit) on TB4. Then connect to appropriate customer E-Stops and other safeguards, as described in this section.



**WARNING:** Adept highly recommends using all of the provided additional customer E-Stop contacts to develop and operate a safe robot workcell that complies with the European safety standards. The robot system must comply with Category 3 (per EN 954) which, according to our risk assessment, is the required category of safety for these Adept robot installations, per EU Directives.

**Table 5-5. Terminal Assignments on TB4 for Customer-Supplied E-Stop Switches**

| Terminal on TB4 | Signal Name                       |
|-----------------|-----------------------------------|
| TB4.1           | Customer E-Stop IN #1             |
| TB4.2           |                                   |
| TB4.3           | Customer Safety Barrier #1        |
| TB4.4           |                                   |
| TB4.5           | Customer Safety Barrier (Mute) #1 |
| TB4.6           |                                   |
| TB4.7           | Customer E-Stop IN #2             |
| TB4.8           |                                   |
| TB4.9           | Customer Safety Barrier #2        |
| TB4.10          |                                   |
| TB4.11          | Customer Safety Barrier (Mute) #2 |
| TB4.12          |                                   |

**NOTE:** If any of the signal pairs in the table above are not connected to customer safety devices, the contacts must be closed with a jumper; otherwise, the E-Stop circuit is not closed and it is not possible to enable High Power. C-shaped metal jumpers are supplied in the accessory kit.

The Category 3 safety system provides two independent E-Stop loops, #1 and #2. The signals designated #1 and #2 represent pairs of signals from a two-pole switch. The #1 switches are in series with the number #1 contacts of the E-Stop switches on the CIP and the MCP. It is the same for the #2 contacts.

The customer E-Stop IN #1 and #2 signals should be from a two-pole switch (or multiple two-pole switches). These contacts are for additional customer E-Stop switches or circuitry, for example, light curtains or pressure-sensitive mats. They would open the E-Stop circuit and shut down High Power when activated.

The customer Safety Barrier #1 and #2 connectors should be from one or more two-pole switches. All the switches that are mounted on safety barriers and safety gates should be installed in series, making two separate loops. Then they are connected to the customer Safety Barrier #1 and #2 input terminals on TB4.

Between the customer Safety Barrier #1 and #2 (Mute) connectors, the same type of switch should be installed as between the connectors described above. In Automatic mode this switch or series of switches has the same function as the normal customer Safety Barrier #1 and #2 connectors, but in Manual mode they are not connected to the chain of E-Stops. In Manual mode these connectors are muted (bypassed) by the control system. This allows you to open an access door to the robot workcell in Manual mode if these limit switches are installed to the customer Safety Barrier #1 and #2 (Mute) contacts.

## Voltage-Free Contacts for Monitoring E-Stop Circuitry (Passive E-Stop)

Adept provides voltage-free contacts (passive E-Stop) on TB5 for monitoring the emergency stop circuitry. The Passive E-Stop output uses positive-drive electromechanical relays that the customer can use to monitor the emergency stop circuit. Many safety standards do not permit electronic control of E-Stop signals; therefore, the passive E-Stop output is often required to ensure that the user's equipment is shut down if an E-Stop is activated.

The Passive E-Stop output should also be used to control any other user devices in the workcell that need to be stopped in an emergency. Such devices might include other moving equipment such as conveyor belts, indexing or transfer devices, pneumatic systems, etc.

The specifications for the relays in the passive E-Stop circuit are:

- Maximum switching power = 250VA (volt amps)/5W
- Maximum switching voltage = 230 Volts AC, 300 Volts DC
- Maximum switching current = 2A



**CAUTION:** The power through the relay must **not** exceed 250VA/5 W.

The user can monitor the condition of the emergency stop circuitry with separate pairs of voltage-free contacts. The names of these two pairs of contacts are customer E-stop #1 OUT and customer E-Stop #2 OUT. These contacts are closed if the E-Stop loop is closed and open if the E-Stop loop is open.

In addition, some users may wish to monitor only the status of the red mushroom push button switches on the CIP or the MCP. The TB5 contacts monitor the status of all emergency stop switches. (See “Category 3 E-Stop Board and Teach Restrict Interface (TRI) Board on Control Rail” on page 113 for details on these connections.)

The System Power OUT is connected to the CIP system power switch. This output can be used to control power to the Adept MV controller and to control auxiliary equipment (using a customer supplied relay or contact).

The terminals for the customer Manual Mode #1 and customer Manual Mode #2 voltage-free contacts are two switches that are closed in Automatic mode and open in Manual mode. These contacts can be used to shut off workcell peripherals (conveyors, feeders, PLCs, network interfaces) when programming the robot in Manual mode. When used in this fashion, the MCP becomes the single point of control for the robot.

The customer Safety Relay IN N/C (normally closed) feedback contacts must be closed with a jumper if they are not used. These contacts must be used to check user-supplied relays in the emergency stop circuit; for example, if there is relay contact in the emergency stop circuit instead of a E-Stop switch.

The terminals for the passive E-Stop and related signals are on terminal block TB5. The following table gives the terminal assignments and the signal names.

**Table 5-6. Terminal Assignment on TB5 for Passive E-Stop Contacts**

| Terminal | Signal Name                                             |
|----------|---------------------------------------------------------|
| TB5.1    | Customer E-Stop #1 OUT, Voltage-Free Contacts           |
| TB5.2    |                                                         |
| TB5.3    | Customer E-Stop #2 OUT, Voltage-Free Contacts           |
| TB5.4    |                                                         |
| TB5.5    | System Power On OUT, Voltage-Free Contacts <sup>a</sup> |
| TB5.6    |                                                         |
| TB5.7    | Customer Manual Mode #1 OUT, Voltage-Free Contacts      |
| TB5.8    |                                                         |
| TB5.9    | Customer Manual Mode #2 OUT, Voltage-Free Contacts      |
| TB5.10   |                                                         |
| TB5.11   | Customer Safety Relay IN Feedback Contacts (N/C)        |
| TB5.12   |                                                         |

<sup>a</sup> The Customer System Power On OUT contacts are connected to the system power switch on the CIP. When this switch is on, the contacts are closed. The System Power On signal can also be used to control auxiliary equipment.

## 5.4 Category 3 Emergency Stop Circuitry

The Category 3 Emergency Stop circuitry is mounted on the Security Panel. The components are on two DIN-rails, the Control Rail and the Power Rail.

The safety relay and power contactor diagram on the following two pages should help you to understand the circuitry and to install the user-supplied parts of the Category 3 Emergency circuit.

**NOTE:** For clarity, some components are omitted, such as current limiting resistors and inductive protection diodes.



**CAUTION:** Applying an external voltage to the customer E-Stop circuit on an MMSP equipped system can permanently damage the E-Stop components.

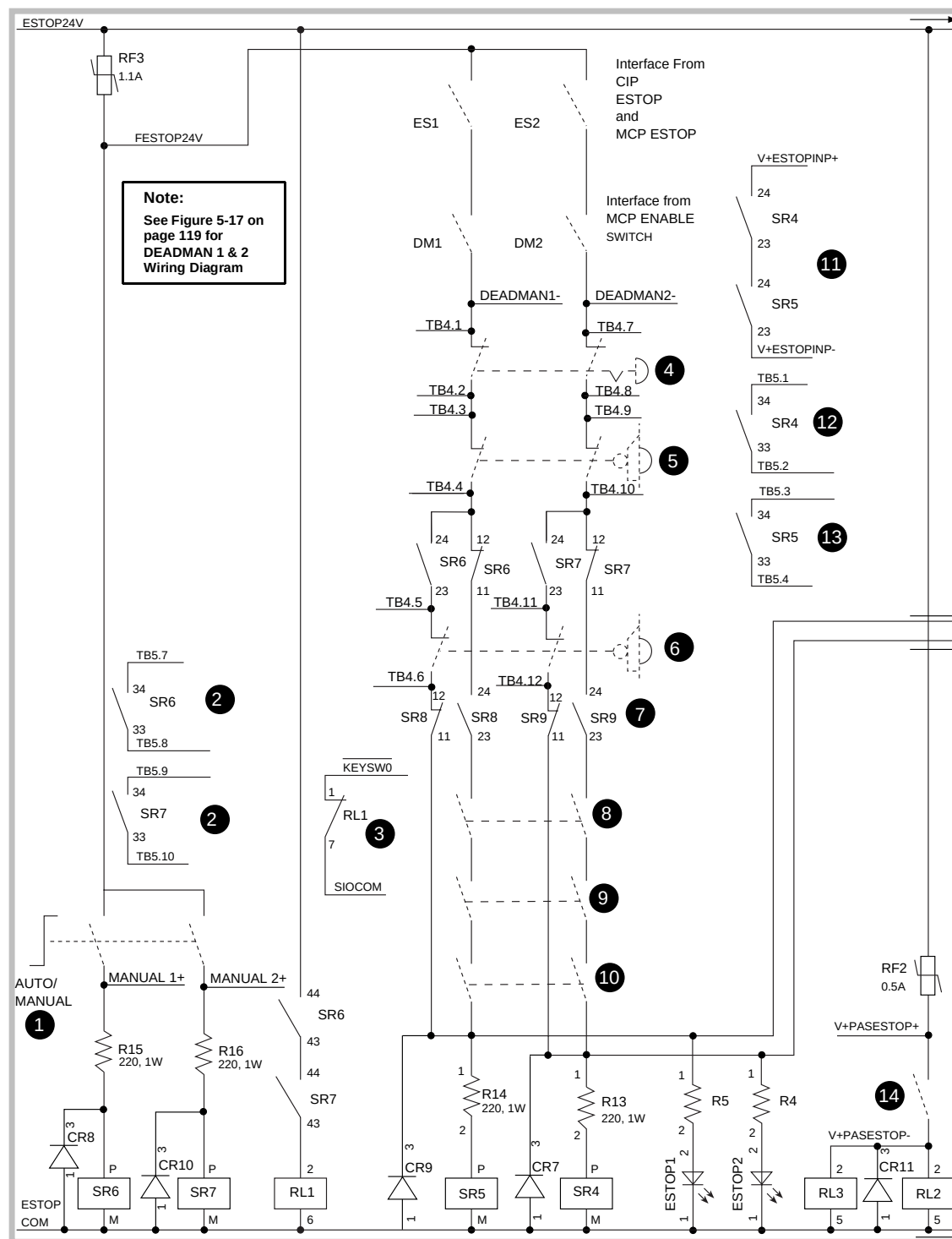
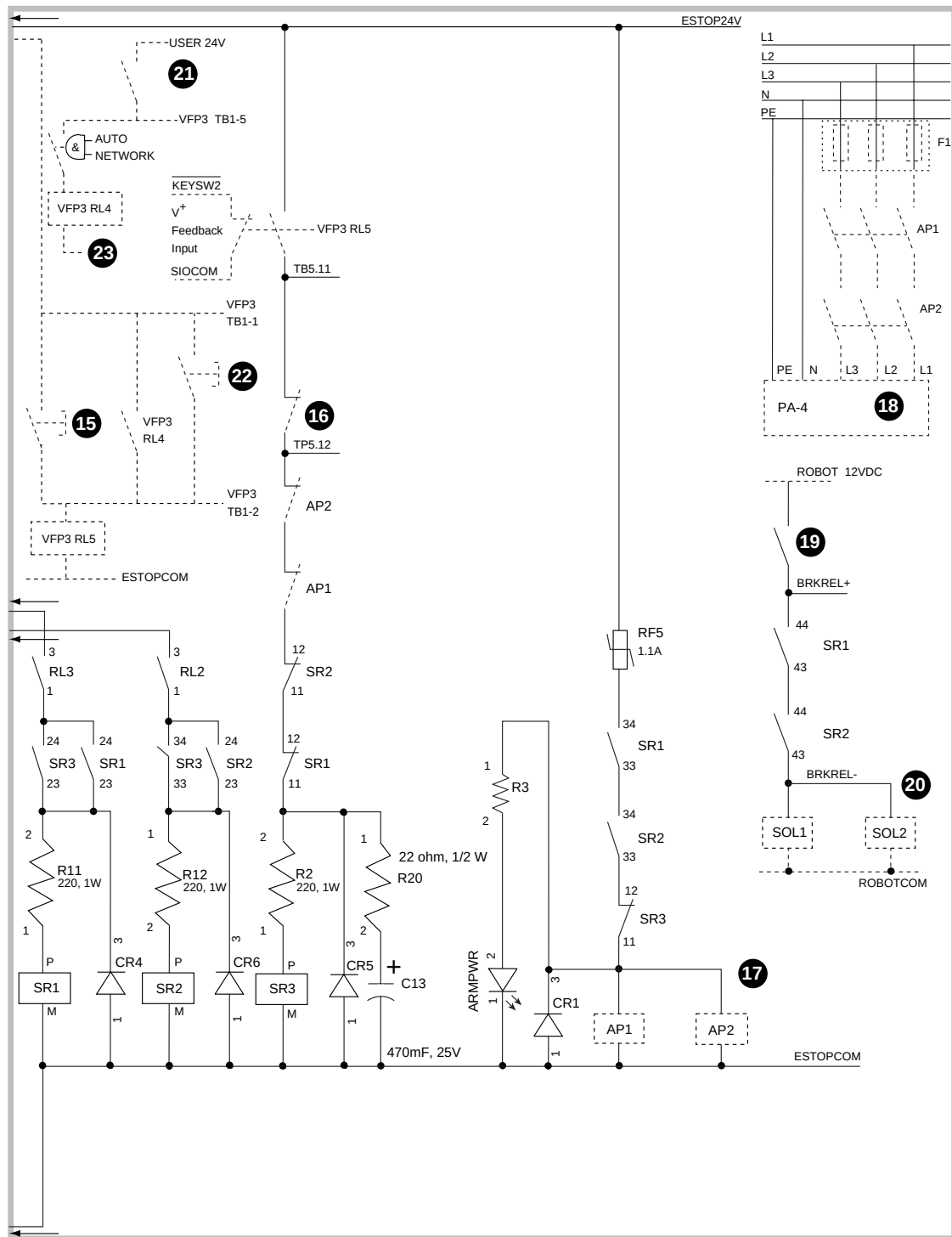


Figure 5-16. Category 3 E-Stop Schematic (Sheet 1 of 2)



**Note:** The description of the numbers are in Table 5-7 on page 120.

**Figure 5-17. Category 3 E-Stop Schematic (Sheet 2 of 2)**

The following table describes the components referred to by the numbers in Figure 5-16 on page 118 and Figure 5-17 on page 119.

**Table 5-7. Description of Numbers in the MMSP 3 E-Stop Drawing**

| No.             | Description of Numbers in the Schematic                                                |
|-----------------|----------------------------------------------------------------------------------------|
| 1               | Front Panel MANUAL/ AUTOMATIC select key switch (MANUAL = Normally Open)               |
| 2               | Customer Manual Mode #1 and #2 OUT, Voltage-Free Contacts                              |
| 3               | V <sup>+</sup> Manual Mode Input Contacts                                              |
| 4               | Customer E-Stop IN #1 and #2 Contacts                                                  |
| 5               | Customer Safety Barrier #1 and #2 Contacts                                             |
| 6               | Customer Safety Barrier (Mute) #1 and #2 Contacts                                      |
| 7               | Teach Restrict Cyclic Check Contacts                                                   |
| 8               | Joint 1 /Joint 2 Accelerometer Contacts                                                |
| 9               | Joint 3 B-Amplifier: Speed Cutoff Contacts                                             |
| 10              | Joint 4 B-Amplifier: Speed Cutoff Contacts                                             |
| 11              | V <sup>+</sup> User External E-Stop Input Contacts (to the CIP passive E-Stop circuit) |
| 12              | Customer E-Stop #1 OUT, Voltage-Free Contacts                                          |
| 13              | Customer E-Stop #2 OUT, Voltage-Free Contacts                                          |
| 14              | V <sup>+</sup> High Power Enable (Passive E-Stop)                                      |
| 15 <sup>a</sup> | CIP High Power ON Remote PUSH Button (MOM)                                             |
| 16              | Customer Safety Relay IN N/C Feedback Contacts                                         |
| 17              | PA4-Power Amplifier Chassis Contactors                                                 |
| 18              | Power Chassis                                                                          |
| 19              | Robot RSC Brake Release Enable Driver                                                  |
| 20              | Robot Brake Release Enable Solenoids                                                   |
| 21 <sup>a</sup> | USER Computer Control Hi Power ON                                                      |
| 22 <sup>a</sup> | (USER) Remote High Power ON P.B. (MOM)                                                 |
| 23              | CIP (JMMSP) TB1-6 USER ground                                                          |

<sup>a</sup> Timing [> 0.1 - 1 second]

## 5.5 Digital Signals on the Category 3 E-Stop Board

The digital input and output signals available to the CIP JSIO connector are wired to terminal blocks TB1, TB2, and TB3 on the security panel (see Figure 5-15). Eleven input and five output channels are available. You can wire these signals using either the JSIO connector on the CIP (see section 7.11) or terminal blocks TB1, TB2, and TB3. See section 7.11 on page 173 and section 7.12 on page 177 for details on wiring to the CIP digital I/O connectors. Wiring to the security panel is described in the following sections.

**NOTE:** The CIP JSIO supports 12 input and eight output channels. However, one input and three outputs are used by the MMSP option and are **not** available to users.

### Input Signals

(See Figure 7-19 on page 175 for a typical input signal circuit.) The terminal blocks TB1 and TB2 handle the digital input signals 1001 to 1011. Each channel has an input and a corresponding return line (refer to Table 5-8 for input specifications). The locations of the signals on the terminal blocks are given in Table 5-9.

**Table 5-8. DIO Input Specifications for TB1 and TB2 on the Security Panel**

|                                                     |                                                        |
|-----------------------------------------------------|--------------------------------------------------------|
| Operational voltage range                           | 0 to 24 VDC                                            |
| “Off” state voltage range                           | 0 to 3 VDC                                             |
| “On” state voltage range                            | 10 to 24 VDC                                           |
| Typical threshold voltage                           | $V_{in} = 8$ VDC                                       |
| Operational current range <sup>a</sup>              | 0 to 20 mA                                             |
| “Off” state current range <sup>a</sup>              | 0 to 1.2 mA                                            |
| “On” state current range <sup>a</sup>               | 7 to 20 mA                                             |
| Typical threshold current, per channel <sup>a</sup> | 10 mA                                                  |
| Impedance ( $V_{in}/I_{in}$ )                       | 1.3 k $\Omega$ minimum                                 |
| Current at $V_{in} = +24$ VDC                       | $I_{in} \leq 20$ mA                                    |
| Turn on response time (hardware)                    | 5 $\mu$ sec maximum                                    |
| Software scan rate/response time                    | 16 ms scan cycle/ 32 ms max response time <sup>b</sup> |
| Turn off response time (hardware)                   | 5 $\mu$ sec maximum                                    |
| Software scan rate/response time                    | 16 ms scan cycle/ 32 ms max response time <sup>b</sup> |

<sup>a</sup> The input current specifications are provided for reference; voltage sources are typically used to drive the inputs.

<sup>b</sup> 2 ms response time (maximum latency) for fast inputs 1001-to-1004, depending on program task configuration, when used with V<sup>+</sup> INTEVENT instruction.

**Table 5-9. Digital Input Signal Assignments on Terminal Blocks TB1 and TB2**

| Terminal Block | Terminal | Signal       | Terminal | Signal      |
|----------------|----------|--------------|----------|-------------|
| TB1            | 1        | 24 V / 1 Amp | 2        | 24 V return |
| TB1            | 3        | Input 1001   | 4        | 1001 return |
| TB1            | 5        | Input 1002   | 6        | 1002 return |
| TB1            | 7        | Input 1003   | 8        | 1003 return |
| TB1            | 9        | Input 1004   | 10       | 1004 return |
| TB1            | 11       | Input 1005   | 12       | 1005 return |
| TB2            | 1        | Input 1006   | 2        | 1006 return |
| TB2            | 3        | Input 1007   | 4        | 1007 return |
| TB2            | 5        | Input 1008   | 6        | 1008 return |
| TB2            | 7        | Input 1009   | 8        | 1009 return |
| TB2            | 9        | Input 1010   | 10       | 1010 return |
| TB2            | 11       | Input 1011   | 12       | 1011 return |

**NOTE:** Digital input signal 1012 is not available because it is used by the MMSP option.

### Output Signals

(See Figure 7-20 on page 176 for a typical output signal circuit.) The terminal block TB3 handles the digital output signals 0001 to 0005 (refer to Table 5-10 for output specifications). The locations of the signals on the terminal block are given in Table 5-11. The terminal blocks provide separate (+) and (–) connections for each channel (no internal common connections). This allows you to wire for current-sourcing or current-sinking mode.

Each output circuit is short-circuit protected.

**Table 5-10. DIO Output Specifications for TB3**

|                                                 |                                                                                                   |
|-------------------------------------------------|---------------------------------------------------------------------------------------------------|
| Operating voltage range                         | 0 to 24 VDC                                                                                       |
| Operational current range, per channel          | $I_{\text{out}} \leq 100 \text{ mA}$                                                              |
| $V_{\text{drop}}$ across output in on condition | $V_{\text{drop}} \leq 0.85 \text{ V}$ at 100 mA<br>$V_{\text{drop}} \leq 0.80 \text{ V}$ at 10 mA |
| Output off leakage current                      | $I_{\text{out}} \leq 600 \text{ }\mu\text{A}$                                                     |
| Turn on response time (hardware)                | 3 $\mu\text{sec}$ maximum                                                                         |
| Software scan rate/response time                | 16 ms scan cycle/ 32 ms max response time                                                         |
| Turn off response time (hardware)               | 200 $\mu\text{sec}$ maximum                                                                       |
| Software scan rate/response time                | 16 ms scan cycle/ 32 ms max response time                                                         |



**CAUTION:** The above specifications for the digital inputs and outputs on the CIP (JSIO) are different from the specifications for a DIO board. Specifically, the CIP (JSIO) output current is limited via short-circuit protection to 100 mA per channel, whereas the DIO output is rated at 400 mA. See the *Adept MV Controller User's Guide* for details on wiring DIO boards.

**Table 5-11. Digital Output Signal Assignments on Terminal Block TB3**

| Terminal Block | Terminal | Signal       | Terminal | Signal       |
|----------------|----------|--------------|----------|--------------|
| TB3            | 1        | 24 V/1 Amp   | 2        | 24 V return  |
| TB3            | 3        | Output 0001+ | 4        | Output 0001– |
| TB3            | 5        | Output 0002+ | 6        | Output 0002– |
| TB3            | 7        | Output 0003+ | 8        | Output 0003– |
| TB3            | 9        | Output 0004+ | 10       | Output 0004– |
| TB3            | 11       | Output 0005+ | 12       | Output 0005– |

**NOTE:** Digital Output signals 0006 to 0008 from the CIP JSIO connector are **not** available because they are used by the MMSP option.



# User Interface Installation

---

# 6

There are three different user interface options for the Adept MV controllers:

- An ASCII interface using a Wyse terminal (or equivalent)
- A graphical user interface using the Adept VGB board, an SVGA monitor, a standard PC-style keyboard, and a serial pointing device.
- A graphical user interface using the AdeptWindows PC software running on a PC (Windows95®, Windows98®, or WindowsNT®).

Installing the three different operator interfaces is covered in this chapter. You need to read only the sections that cover the type of interface you are installing.

The type of interface that V<sup>+</sup> expects when it initializes depends on the options ordered with your system. If your system was ordered with the AdeptWindows PC option, V<sup>+</sup> will initialize and expect the operator interface to be made using a PC computer equipped with the Adept Windows PC software (see section 6.3).

If your system is not ordered with the AdeptWindows PC option, V<sup>+</sup> will initialize and expect the operator interface to be made using either:

- A user-supplied terminal connected to the RS-232/TERM connector on the AWC board (see section 6.2) or
- The monitor, keyboard, and pointing device connected to the optional VGB board (see section 6.1).

(Systems without the AdeptWindows PC option will automatically select the correct of these two options depending on what hardware you connect.)

**NOTE:** The system start-up behavior is determined by the configuration DIP switch on the AWC board and the “software” DIP switch settings in the controller NVRAM. The instructions in this section assume that both of these DIP switches have been left in their factory default settings. If you have changed these settings or wish to change the start-up behavior of the system, see the *Adept MV Controller User’s Guide* for details on the AWC DIP switch settings and the *Instructions for Adept Utility Programs* for details on the “software” DIP switch settings.

## 6.1 Graphical User Interface Using the VGB Board

If you ordered this type of interface, the VGB board is already installed. There is no hardware or software configuration. You simply install the monitor, keyboard, and pointing device. The user interface will be available as soon as you turn on the system.

**NOTE:** The keyboard and monitor supplied by Adept are intended for use in light industrial conditions. In more severe conditions, they should be protected with a suitable enclosure.

### Installation Procedure

Connect the color monitor and extended keyboard with built-in trackball to the VGB board (see Figure 6-1).

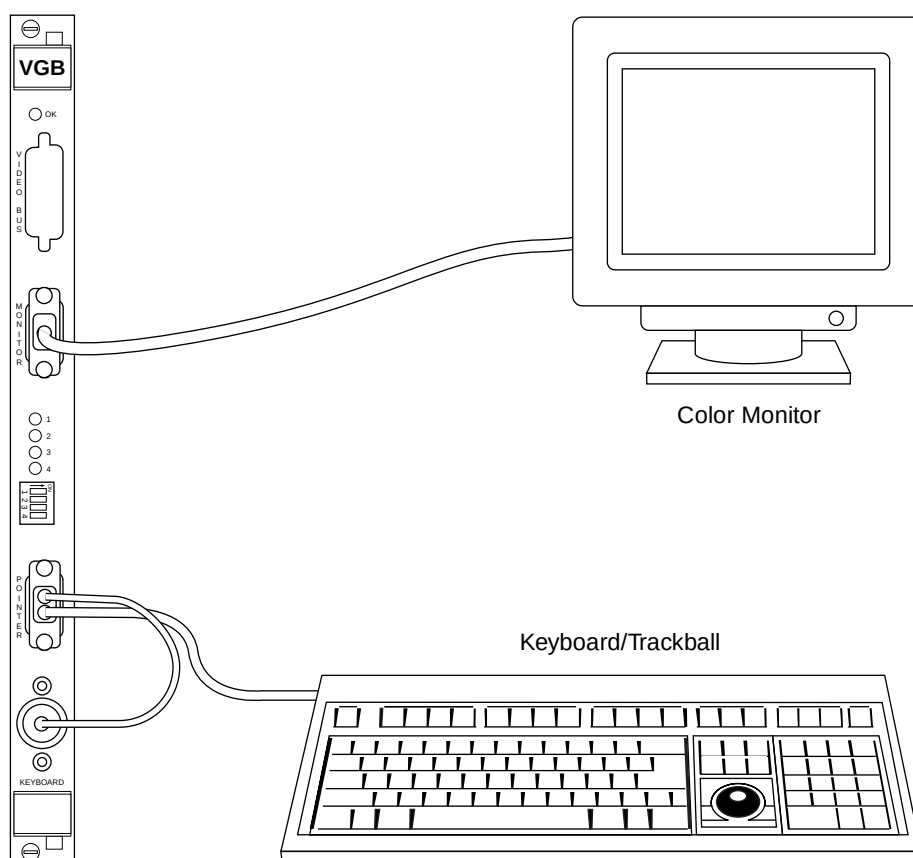


**Figure 6-1. Connecting the A-Series Monitor and Keyboard**

1. Make sure the controller is turned off before making any connections. Connect the monitor signal cable to the MONITOR connector on the VGB board.

See the *Adept MV Controller User's Guide* for monitor specifications for user-supplied monitors.

2. Verify that the voltage range marked on the monitor is compatible with your local voltage source. Connect the monitor AC power cord to the monitor, then plug it into an appropriate voltage source.

3. Connect the double-ended keyboard cable to the KEYBOARD connector and the POINTER connector on the VGB board. A standard PC-style 101 key keyboard can be used instead of the Adept-supplied keyboard. A pointing device that is compatible with Microsoft serial mouse protocols can be used instead of the Adept-supplied integrated trackball.

For systems with the optional AdeptVision system, camera output will be displayed at full frame rates in the vision window on the monitor. If you have purchased the AdeptVision option, the system is installed. If you are adding the AdeptVision option to an existing system, see the *Adept MV Controller User's Guide* for installation details.

## 6.2 Text-Based Interface Using a Terminal

With an Adept MV controller system that does not have one of the graphical user interface options, the customer must supply the terminal and cable to interface to the controller. The terminal must be a Wyse Model 60 or 75 with an ANSI keyboard, or a compatible terminal. You may also be able to use a computer with suitable terminal emulation software. For DOS or Windows-compatible computers, the programs “Procomm+” or “Procomm for Windows” (available from many computer stores) include software emulation for the Wyse-75.

This type of interface is not suitable for any graphics-based programming, graphics-based application programs such as AIM, or systems equipped with the vision option.

### Recommended Terminal for Text-Based Systems

The recommended terminal for use with the Adept MV controller is the Wyse WY-60. You must also specify the Wyse ANSI/VT100 style keyboard (Wyse p/n 900127-02 or 900128-02). Note: The WY-60 is also available with ASCII and IBM Enhanced PC keyboards. These are *not* Adept-compatible. You must make sure you order the correct keyboard. The WY-60 is available in both 220V and 110V versions.

### Installation Procedure

1. Make sure the controller is turned off before making any connections.
2. Verify the voltage range marked on the terminal is compatible with your local voltage source. Connect the AC power cord to the terminal, then plug it into an appropriate voltage source.
3. Connect a suitable serial cable between the terminal and the RS-232/TERM connector on the AWC board. (If you need to fabricate this cable, see the *Adept MV Controller User's Guide* for the RS232/TERM pin location and description.)
4. If the terminal is a Wyse 60, use the setup mode to set the personality to “WY-75”. If you are using terminal emulation software on a computer, set the software to “WY-75” emulation. If “WY-75” is not available, try “VT102” or “VT100” (you will not be able to use all of the function keys).
5. Set the terminal baud rate to 9600, the default rate for the Adept system. To change the baud rate, refer to the information on CONFIG\_C in the *Instructions for Adept Utility Programs*.

## 6.3 Graphical Interface Using AdeptWindows PC

The AdeptWindows PC Microsoft Windows® based program allows full programming and control of the robot from an IBM compatible personal computer. The computer can be connected to the Adept controller using a serial cable or an Ethernet link.

This section details the simple connection of one PC to one Adept controller. AdeptWindows software allows for more complex installations on a network. For instructions on installing and configuring more complex installations, see the *AdeptWindows User's Guide*. The following instructions assume that the configuration DIP switches and network section of the Adept system configuration have been left as delivered.

Installing an AdeptWindows PC based user interface involves the following steps:

- Install the AdeptWindows PC software on the customer-supplied PC.
- If you are using an Ethernet connection:
  - Set up the TCP/IP interface.
  - Connect the Adept controller to the PC using a customer-supplied network hub or an Ethernet crossover cable. (A crossover cable can be purchased from Adept.)
- If you are using a serial connection:
  - Connect the Adept controller to the PC using a standard serial cable. Use the RS232/TERM serial port on the AWC board.

### Installing the AdeptWindows Software

The AdeptWindows software for the PC is distributed on one diskette. The disk contains an installation program to properly install the software on the PC. The following programs will be installed:

- AdeptWindows PC
- AdeptWindows Off-line Editor
- AdeptWindows DDE Server
- AdeptWindows TFTP Server

After installation, each of these programs can be started from the Windows Start menu bar.

**NOTE:** All the above applications are installed. However, only AdeptWindows PC is required for the operator interface.

To install the software:

1. Make a note of the keyword on the AdeptWindows Installation Disk and insert the disk in the 3.5" floppy drive (typically drive A) of your PC.
2. From the Start menu bar in Windows:

**Start ➡ Run**

The following dialog box is displayed:

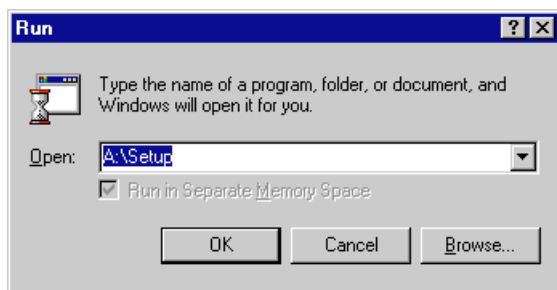


**Figure 6-2. AdeptWindows Installation**

3. Type A:\SETUP in the text box.
4. Choose **OK** to start the installation process. By default, the software is installed into the subdirectory

C:\Adept\AdeptWindows

on the hard drive of your PC. You can specify a different directory if desired.

Additionally, during installation, the software automatically creates the sub-directory

C:\Adept\Disks\Disk\_C

which can be mounted as an NFS directory by the Adept controller. See the *AdeptWindows User's Guide* for details.

5. When the installation program prompts you for the keyword, enter the characters noted in Step 1 from the label on your AdeptWindows disk.

**NOTE:** Do not confuse the keyword for the AdeptWindows software on the PC with the password for the AdeptWindows license on the Adept controller.

## Setting Up the TCP/IP Interface (Ethernet Connection)

The IP address is the logical means by which the higher level Ethernet software identifies a specific node. The IP address must be unique for each node within a LAN.

The network address and sub-net mask of the PC must be set to:

IP Address:        172.16 .200. xx  
Subnet Mask:     255.255. 0 . 0

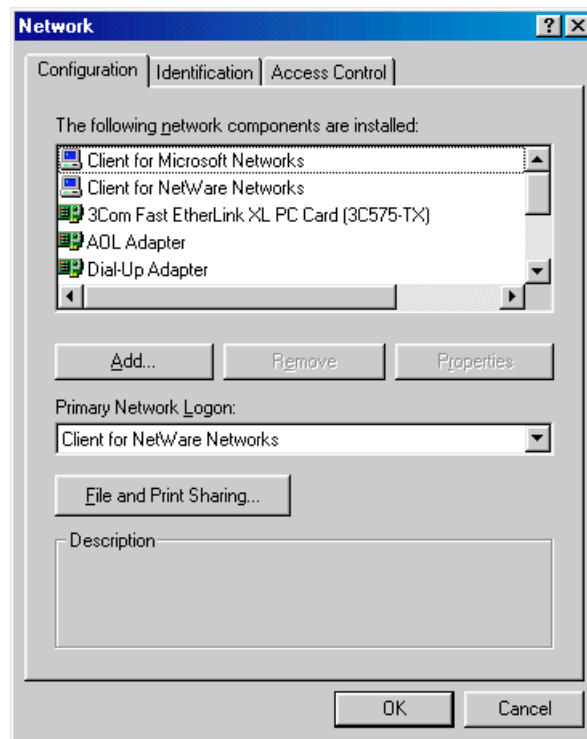
Where "xx" can be any number from 1 to 255.

To setup the TCP/IP interface on your computer:

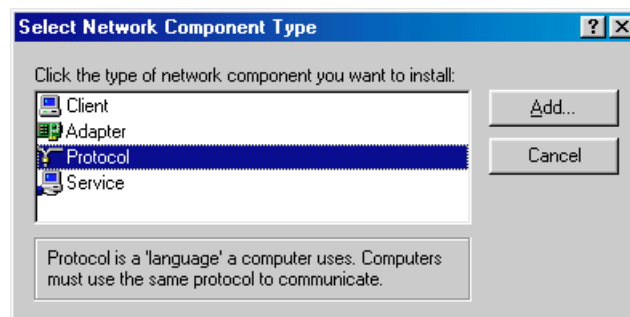
1. Make sure the network interface card on your computer is properly installed and then start your PC.
2. Open the Network parameters window:

**Start ➡ Settings ➡ Control Panel ➡ Network**

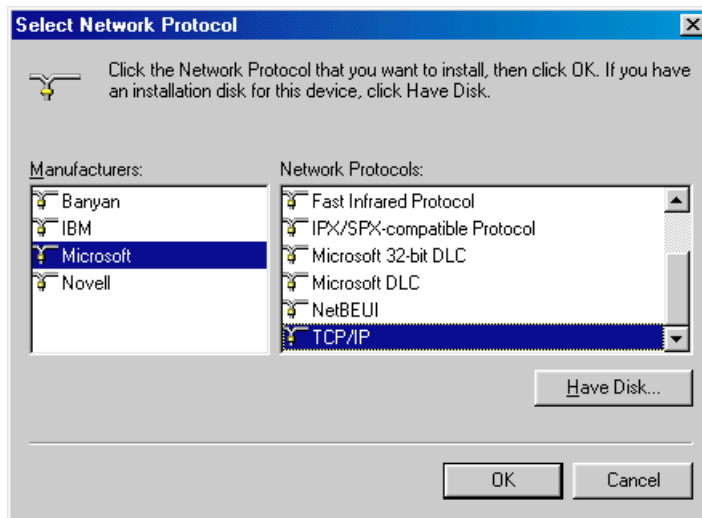
The following window is displayed:



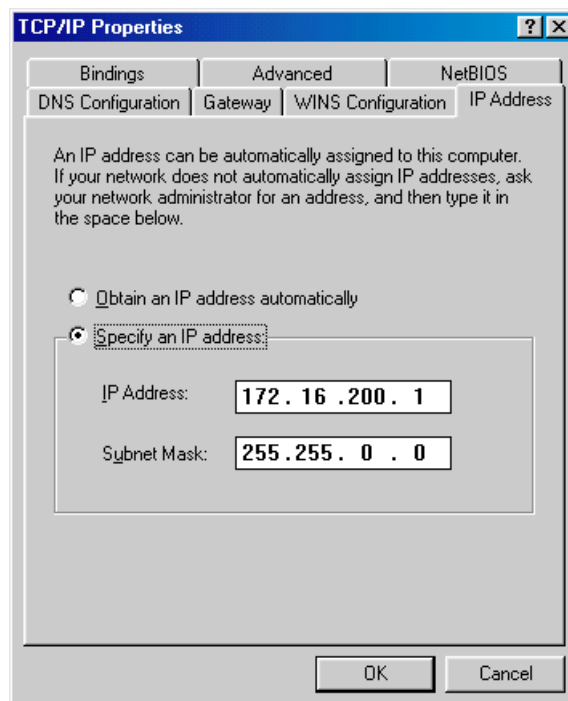
3. Click on the **Add** button, and the following window is displayed:



4. Click on Protocol and then click on the **Add** button, and the following window is displayed:



5. Click on **Microsoft** in the left scrolling window and then scroll down the right scrolling window until you can click on **TCP/IP**. Click on the **OK** button. The network parameters window is redisplayed. Click on the TCP/IP protocol that you have just added and then click on **Properties**. When the TCP/IP Properties windows is displayed, select the **IP Address** tab. The following window is displayed:



6. Click on **Specify an IP address** and then enter the numbers shown above. Click on the **OK** button.
7. Restart your computer.

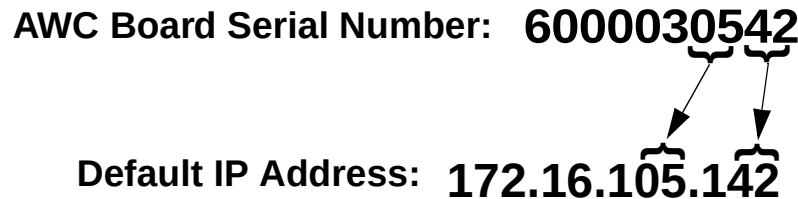
See the documentation provided with your PC for further details on installing a TCP/IP protocol and setting the network address and sub-net mask.

The IP address for the AWC board is already set based on the board's serial number (the board serial number is *not* the same as the controller's serial number). The default IP address will be:

172.16.1xx.1yy

where "xx" and "yy" are the last 4 decimal digits of the AWC board's serial number.

**AWC Board Serial Number: 6000030542**



**Default IP Address: 172.16.105.142**

**Figure 6-3. The Controller IP Address**

**NOTE:** The AWC board serial number is located on the top front of the AWC board and on a bar code label attached to the bus connectors at the rear of the board.

As shown in Figure 6-3, if the AWC board serial number is 6000030542, the Adept controller's default IP address will be:

172.16.105.142

## Connecting One PC and One Controller

As shown in Figure 6-4, there is one PC networked to one Adept controller. The AWC board can be connected to the PC using one of the three cabling options shown below.

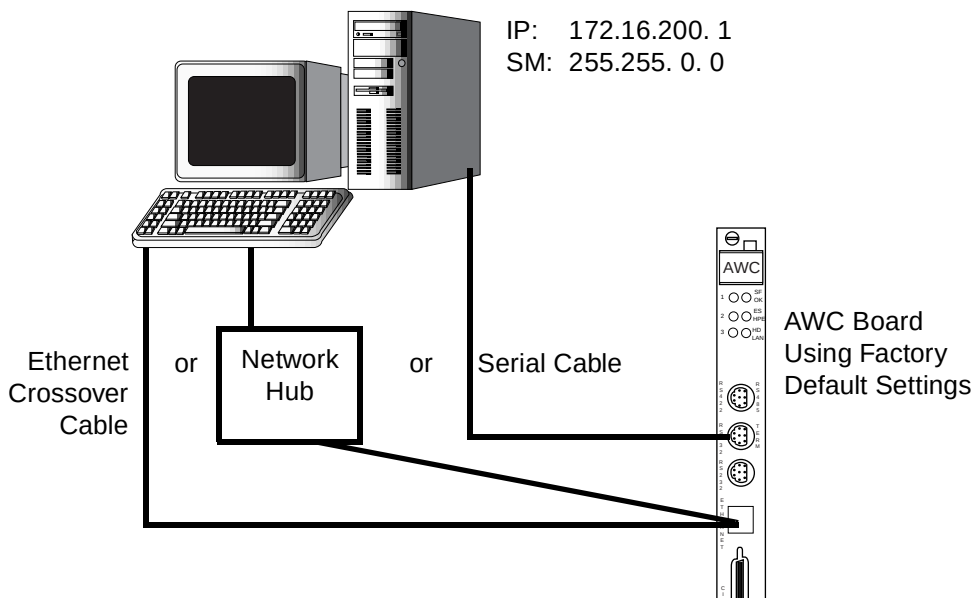


**Figure 6-4. One PC, One Controller**

To create the network shown in Figure 6-4, complete the following steps:

1. Install the AdeptWindows software on the PC. See "Installing the AdeptWindows Software" on page 129.
2. If you are making an Ethernet connection:
  - a. Connect the Adept controller to your PC using a network hub or a crossover cable.
  - b. Install a TCP/IP protocol on the PC using the IP address and subnet mask shown in Figure 6-4. See "Setting Up the TCP/IP Interface (Ethernet Connection)" on page 130 and the documentation for your PC for details.

If you are making a serial connection:

- a. Connect the Adept controller to your PC using a serial cable. Plug one end of the cable into the RS232/TERM connector on the AWC board and the other end into an available serial port on the PC.
3. Start the Adept controller.
4. Start the PC.



**WARNING:** Since the entire robot installation has not yet been verified, *do not* turn on the PA-4 power chassis.

5. Start AdeptWindows on the PC and make a logical connection to the controller. If you are using an Ethernet connection:

- a. Select the **File ➡ Scan Ethernet** option. If the configuration of your PC is correct, you will see the IP address of the Adept controller.
- b. Select **File ➡ Connect Via Ethernet**. Enter the controller IP address and click on **OK**. (The AdeptWindows PC software will present the last used IP address as the default.)

If you are making a serial connection:

- a. Select **File ➡ Connect Via COM port**.
  - b. Select the COM port being used on your PC and press **OK**.
6. The V<sup>+</sup> monitor window will be displayed.



# Optional Equipment Installation

# 7

## 7.1 User Signal and Solenoid Driver Lines

There are several pairs of wires routed from the rear of the robot to the tower assembly of the Adept-XL robot. These are referred to as User Signal Lines and may be used as signal lines for equipment mounted on the outer link or the tool flange. The tower assembly is located under the quill cover (see Figure 7-1). The pinouts for the User lines are shown in Table 7-1 on page 140.

### USER1-1 Through USER 2-4

USER1-1 through USER2-4 line pairs run from the robot tower (see Figure 7-1 on page 138) to the User connectors on the Arm Signal cable (see Table 7-1 on page 140). These lines can be used to connect limit switches or similar digital devices to the digital I/O of the controller. See the *MV Controller User's Guide* for further information on digital I/O.

**NOTE:** The MMSP option (see Chapter 5) uses the signal lines on the User2 connectors; these lines are not available for customer use.



**CAUTION:** User lines are routed through the robot harness in close proximity to robot control signals. To ensure long life, these lines are constructed from 28 AWG high-strand-count wires and are not designed to carry high current or high voltage. These lines should be limited to a maximum of 24 VDC at 2 Amps. To minimize coupling with robot control signals in adjacent harnesses, you should minimize voltage transients and maintain a current balance in each +/– pair. Exceeding these recommendations could couple noise onto the robot control lines and cause robot motion errors.

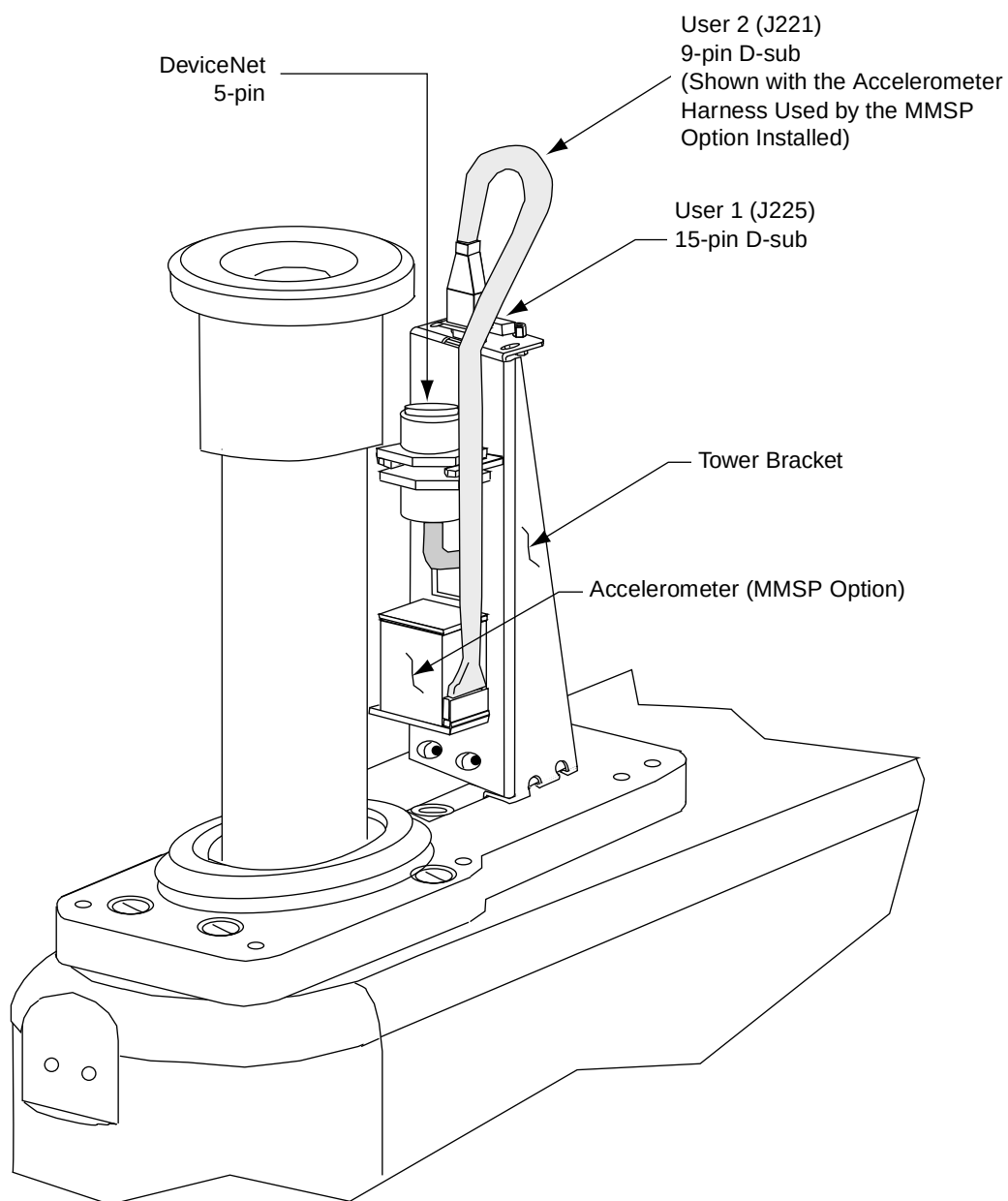


**Figure 7-1. User Connector Locations on the Tower Assembly**

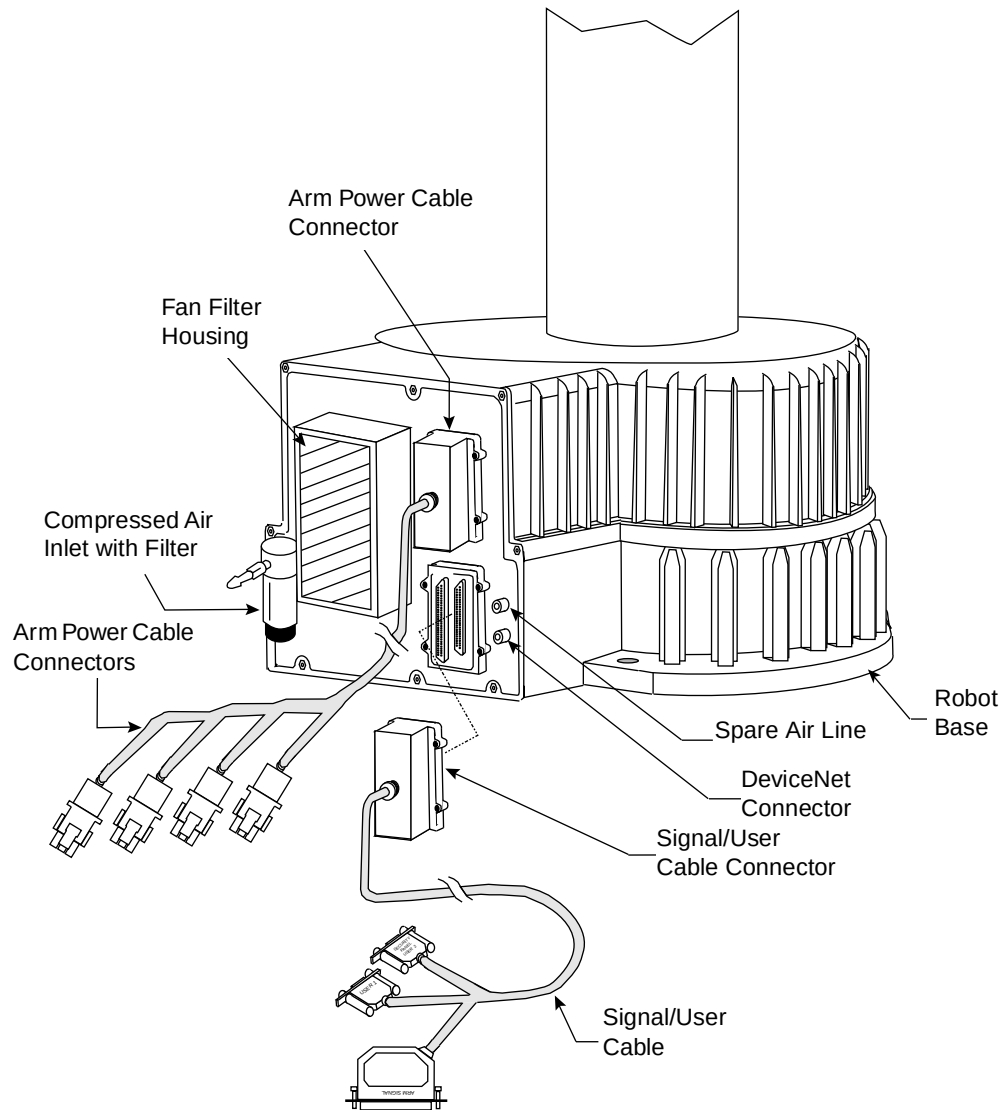


**Figure 7-2. Adept-XL Robot Base Showing Air Filter and Cable Connector Locations**

Table 7-1. Pinouts for User Connectors

| Connectors on Robot Tower |          | Connectors on Arm Signal Cable |               |                |               |
|---------------------------|----------|--------------------------------|---------------|----------------|---------------|
| USER1 J221 15-Pin         |          | 25-Pin (at robot base)         |               | USER1 15-Pin   |               |
| Pin No.                   | Signal   | Pin No.                        | Signal        | Pin No.        | Signal        |
| 1                         | USER1-1+ | 1                              | USER1-1+      | 1              | USER1-1+      |
| 2                         | USER1-1- | 2                              | USER1-1-      | 2              | USER1-1-      |
| 3                         | USER1-2+ | 3                              | USER1-2+      | 3              | USER1-2+      |
| 4                         | USER1-2- | 4                              | USER1-2-      | 4              | USER1-2-      |
| 5                         | USER1-3+ | 5                              | USER1-3+      | 5              | USER1-3+      |
| 6                         | USER1-3- | 6                              | USER1-3-      | 6              | USER1-3-      |
| 7                         | USER1-4+ | 7                              | USER1-4+      | 7              | USER1-4+      |
| 8                         | USER1-4- | 8                              | USER1-4-      | 8              | USER1-4-      |
| 9                         | USER1-5+ | 9                              | USER1-5+      | 9              | USER1-5+      |
| 10                        | USER1-5- | 10                             | USER1-5-      | 10             | USER1-5-      |
| 11                        | USER1-6+ | 11                             | USER1-6+      | 11             | USER1-6+      |
| 12                        | USER1-6- | 12                             | USER1-6-      | 12             | USER1-6-      |
| 13                        | Not used | 13                             | Not used      | 13             | Not used      |
| 14                        | Not used | 14                             | USER2-1+      | 14             | Not used      |
| 15                        | Not used | 15                             | USER2-1-      | 15             | Not used      |
| SHLD FOR USER1            |          | 16                             | USER2-2+      | SHLD FOR USER1 |               |
|                           |          | 17                             | USER2-2-      |                |               |
| USER2 J225 9-Pin          |          | 18                             | USER2-3+      | USER2 15-Pin   |               |
| Pin No.                   | Signal   | 19                             | USER2-3-      | Pin No.        | Signal        |
| 1                         | USER2-1+ | 20                             | USER2-4+      | 1              | USER2-1+      |
| 2                         | USER2-1- | 21                             | USER2-4-      | 2              | USER2-1-      |
| 3                         | USER2-2+ | 22                             | Not used      | 3              | USER2-2+      |
| 4                         | USER2-2- | 23                             | Not used      | 4              | USER2-2-      |
| 5                         | USER2-3+ | 24                             | Not available | 5              | USER2-3+      |
| 6                         | USER2-3- | 25                             | Not available | 6              | USER2-3-      |
| 7                         | USER2-4+ | SHLD FOR USER1 & 2             |               | 7              | USER2-4+      |
| 8                         | USER2-4- |                                |               | 8              | USER2-4-      |
| 9                         | Not used |                                |               | 9-10           | Not available |
| SHLD FOR USER2            |          |                                |               | 11-15          | Not used      |
|                           |          |                                |               | SHLD FOR USER2 |               |

## 7.2 Adept-XL Joint 5 Wiring

Wiring is provided for an optional Joint 5 axis. Contact Adept RDA services group for specifications on the Adept-XL series Joint 5 option (see “How Can I Get Help?” on page 41).

**NOTE:** The Adept Joint 5 used with non-XL series AdeptOne robots is **not** compatible with the AdeptOne-XL robot.



**CAUTION:** The Joint 5 wiring is designated to be used only for that purpose and should not be used to drive peripheral devices. Damage to your equipment can result from improper use of this wiring.

## 7.3 Adept-XL Robot Solenoid Kit

This section describes mounting the 24V solenoid option kit on an Adept-XL Robot. The solenoid kit, Adept P/N 90862-00100, is available through Adept.

**NOTE:** The valves are mounted inside the outer link cover.

The robot has been prewired for a bank of four 24 VDC solenoid valves. Power and signal lines for the solenoids are terminated at a 9-pin D-sub connector mounted inside the outer link cover (see Figure 7-4 on page 144). The signals actuating the valves are directly switchable from  $V^+$  using software signals 3001 and 3002. Refer to the SIGNAL, OPEN, OPENI, CLOSE, and CLOSEI commands in the  $V^+$  *Language Reference Guide* for additional information. Each driver is designed to handle 24 VDC solenoids at a nominal 0.075 mA per valve.

The solenoid valve assembly, Adept P/N 30862-00100, consists of four independent valves (valve #1 through valve #4) on a common manifold (see Figure 7-3). The manifold supplies air at the user's line pressure (70 psi minimum to 110 psi maximum). Each valve has two output ports, A and B. The output ports are arranged so that when port A is pressurized, port B is not pressurized. Conversely, when port B is pressurized, port A is not. In the Adept-XL robot, the air lines from port A on each valve are plugged at the factory (at the solenoid assembly).

### Tools Required

- M2.5 Allen driver
- M4 Allen driver
- Eight cable tie-wraps
- Pair of diagonal wire cutters
- Solenoid valve upgrade kit (Adept P/N 90862-00100)
- Open end wrenches (7/8 in.)

### Installation Procedure

#### Install the 24 Volt Valve Assembly

1. Turn off power to the PA-4 power chassis.

2. Remove air pressure from the robot.
3. Plug the four individual two-wire connectors on the valve harness into the solenoid valves. Match each connector to the appropriate valve as follows (see Figure 7-4 on page 144):
  - SOL 1 to valve #1
  - SOL 2 to valve #2
  - SOL 3 to valve #3
  - SOL 4 to valve #4.
4. Mount the Adept-XL 24V solenoid valve assembly, P/N 30862-00100, to the joint 2 upper cover using (see Figure 7-4 on page 144):
  - (Two) M3 X 25 mm socket head cap screws (P/N 51001-65025)
  - (Two) M3 stainless steel flat washers (P/N 54000-96500)
  - Loctite 222 thread-locking adhesive (P/N 87002-00222)
5. Cut several lengths of tubing (provided in the kit) according to the measurements given in Table 7-2.

**Table 7-2. Nylon Tubing Lengths**

| Tubing                  | Quantity | Length            | Label in Diagrams |
|-------------------------|----------|-------------------|-------------------|
| 5/32 inch natural nylon | 4        | 228 cm (90 in.)   | A1 - A4           |
| 1/4 inch natural nylon  | 1        | 83 mm (3 1/4 in.) | B                 |
|                         | 1        | 96 mm (3 3/4 in.) | C                 |
|                         | 1        | 205 mm (8 in.)    | D                 |
| 1/4 inch yellow nylon   | 1        | 423 mm (16.5 in.) | E                 |

6. Connect tube B (83 mm [3-1/4 in.]) and tube C (96 mm [3-3/4 in.]) to the dual end of the 1/4 inch Y-union connector (P/N 42066-14000).
7. Connect tube D (205 mm [8 in.]) to the single end of the 1/4 inch Y-union connector.
8. Connect tube B and tube C to the pair of fittings shown in Figure 7-3.
9. Connect tube E to the 1/4 inch inlet elbow of the valve assembly as shown in Figure 7-3.

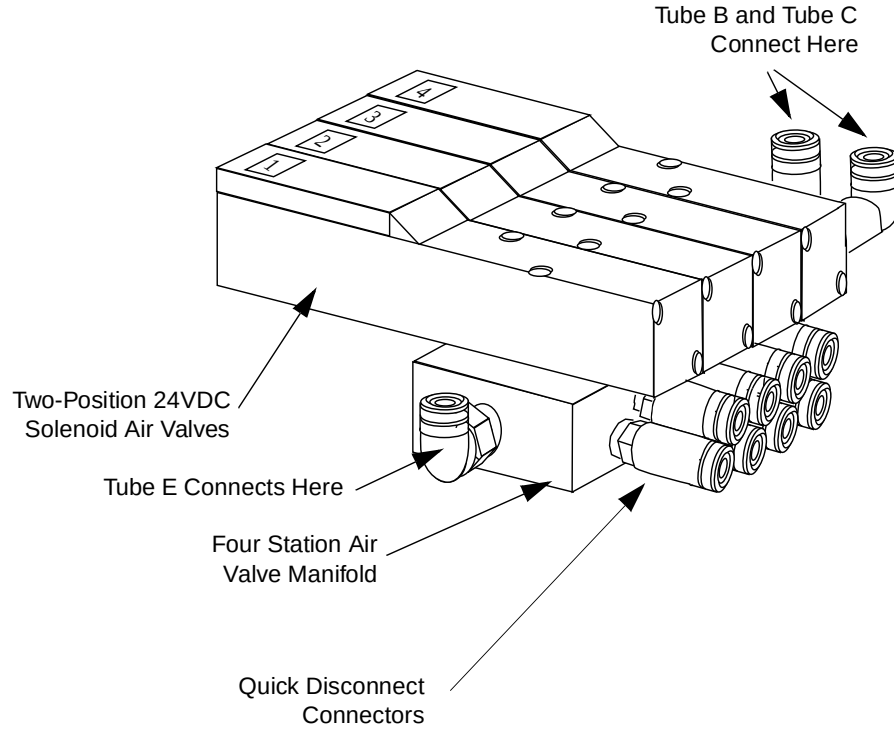


**Figure 7-3. Gripper Solenoids, Connector Locations**

10. Identify tubes A1 - A4 (228 cm [90 in]) by marking each end with wire markers.
11. Wire tie tubes A1 - A4 into pairs (A1/A2 and A3/A4).
12. Starting from the outer link housing access port, route tubes A1 - A4 through the left side cable tray in the outer link (see Figure 7-5). Bring the tubing up through the tower bracket, one pair on each side of the bracket. Route the air lines through the quill (see Figure 7-6).

Leave approximately 61 cm (24 in) of tubes A1 - A4 extending from the edge of the outer link cable tray.

**NOTE:** Left is as viewed from the rear of the robot.

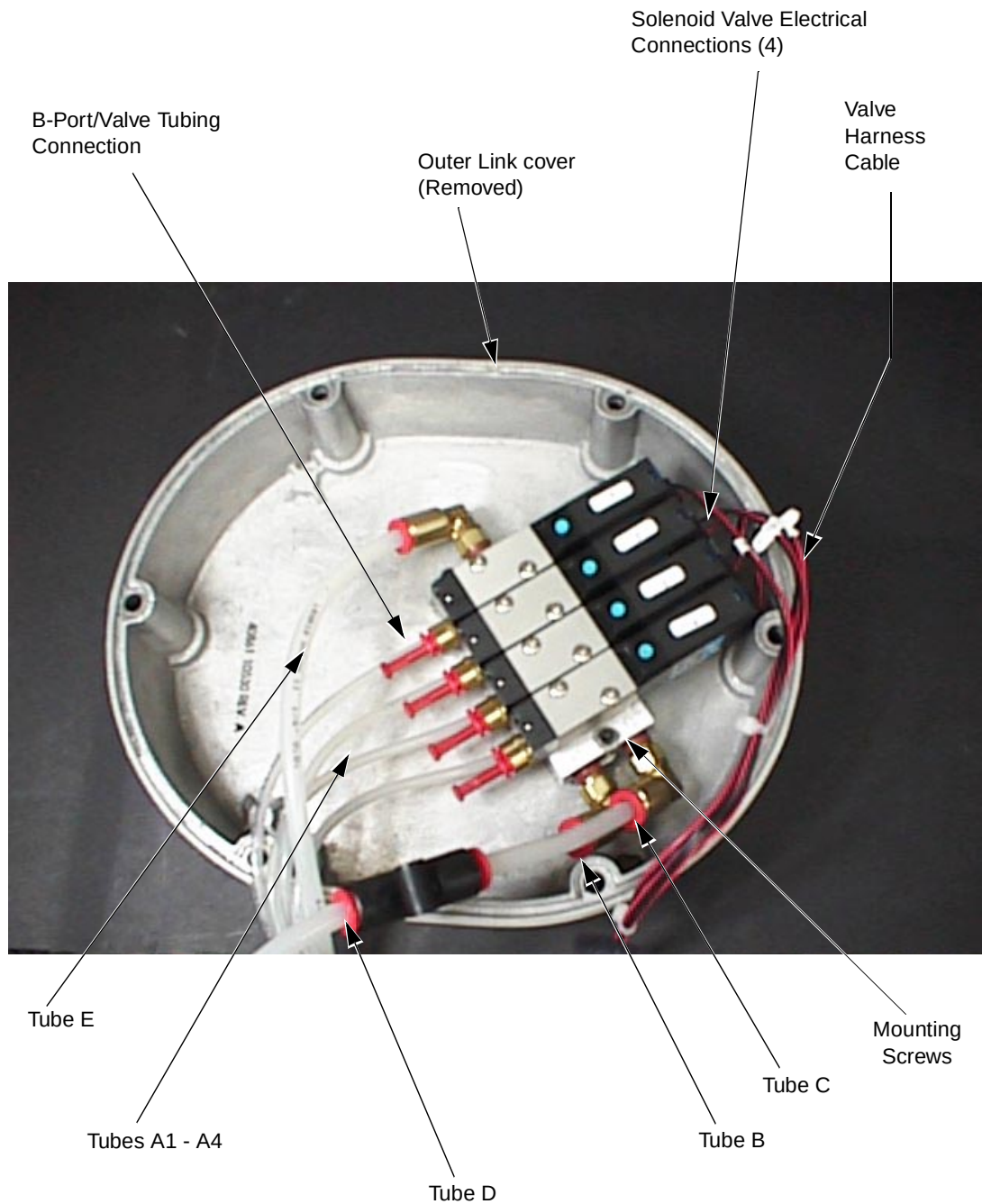


**Figure 7-4. Solenoid Valve Assembly**

13. Route tubes A1 - A4 along the outer link inside wall so that the tubing will **not** interfere with existing wiring. Use the 4-inch cable-ties (P/N 27300-00023) as required to hold the tubing together (see Figure 7-5).

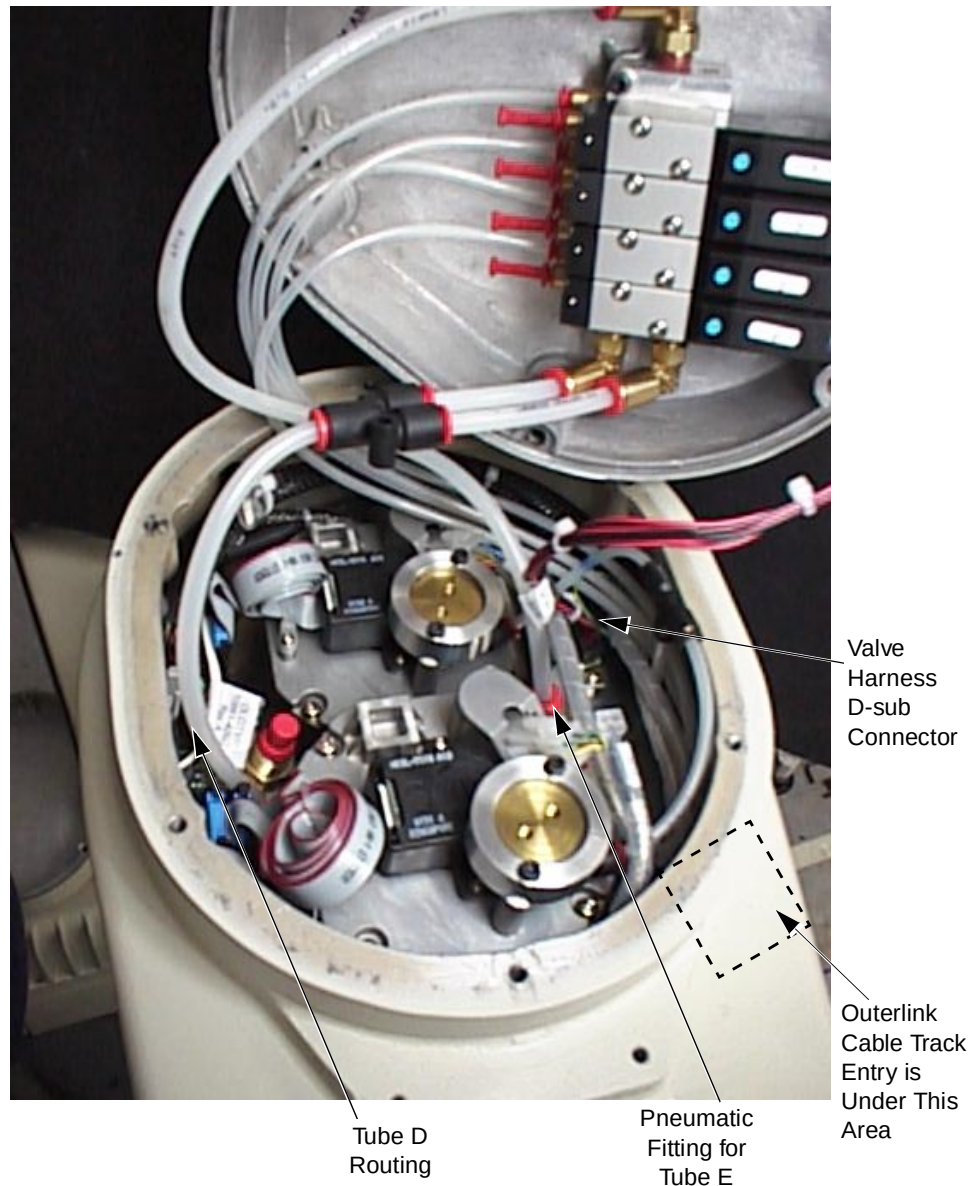


**Figure 7-5. Tube and Cable Routing**

14. Remove the 1/4 inch plug from the pneumatic fitting on the left bulkhead. Insert tube E into the fitting and make a loop that will allow the outer link cover to be installed without interference from tube E.
15. Connect tubes A1 - A4 to the "B" ports of the four valves. Group the tubes by pairs so that they are in adjacent valves. Adjust the tubing lengths as needed by pushing the tubes out through the tower bracket (see Figure 7-6 on page 146).
16. Connect the D-sub connector on the solenoid valve harness to the connector on the outer link left bulkhead (see Figure 7-5). Route the harness along the four 5/32 inch pneumatic tubes. Secure the captive screws on the D-sub connector.
17. Route tube D as shown in Figure 7-5.

18. Verify that none of the existing connectors on the printed circuit board have been disconnected.
19. Carefully lower the joint 2 upper cover into place and secure the cover with the original hardware. Use Loctite 242 on the fasteners.
20. Move joint 3 all the way to the lower hard stop. Ensure that the four air lines do not have an excessively sharp bend radius (top of the radius is 1 to 2 inches above the top of the ball spline as shown in Figure 7-6). Cut tubes A1 - A4 so that the air lines are 1 to 2 inches below the face of the user flange and replace the wire markers.
21. Install a cable-tie on each pair of 5/32 inch air lines above the tower bracket (see Figure 7-6).
22. Install the four 5/32 inch tube unions (P/N 42066-92000).
23. Install the four 5/32 inch plugs (P/N 42055-12000).



**Figure 7-6. Tower Bracket Tubing/Cable-Tie Installation**

### Test the Gripper Valves

As part of the commissioning process described in Chapter 8, test the operation of the hand valves by issuing the following V<sup>+</sup> monitor commands and verifying that the results listed in Table 7-3 are correct.

**Table 7-3. User Air Line Command Summary**

| State   | Pneumatic Action on Port B*                                                          | V <sup>+</sup> Command                                    | MCP Procedure                                                                      |
|---------|--------------------------------------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------------------------------|
| Open    | Pressure at valve 1 on port B,<br>no pressure at valve 2 on port B**                 | DO OPENI<br>(or)<br>SIGNAL -3001, +3002                   | In World, Tool, or<br>Joint state, press T1<br>and plus speed bar                  |
| Closed  | Pressure at valve 2 on port B,<br>no pressure at valve 1 on port B**                 | DO CLOSEI<br>(or)<br>SIGNAL +3001, -3002                  | In World, Tool, or<br>Joint state, press T1<br>and minus speed bar                 |
| Open    | (option)<br><br>Pressure at valve 3 on port B,<br>no pressure at valve 4 on port B** | (option)<br><br>DO OPENI<br>(or)<br>SIGNAL -3003, +3004   | (option)<br><br>In World, Tool, or<br>Joint state, press T1<br>and plus speed bar  |
| Closed  | (option)<br><br>Pressure at valve 4 on port B,<br>no pressure at valve 3 on port B** | (option)<br><br>DO CLOSEI<br>(or)<br>SIGNAL +3003, -3004  | (option)<br><br>In World, Tool, or<br>Joint state, press T1<br>and minus speed bar |
| Relaxed | No pressure at either valves 1, 2,<br>3 or 4 on<br>port B**                          | DO RELAXI<br>(or)<br>SIGNAL -3001, -3002,<br>-3003, -3004 | In Free state, press T1                                                            |

\*Pneumatic action on port A will be the opposite of port B.

\*\*No pressure indicates that the valve is connected to the return exhaust.

## Compressed Air Lines In the Adept-XL Robot

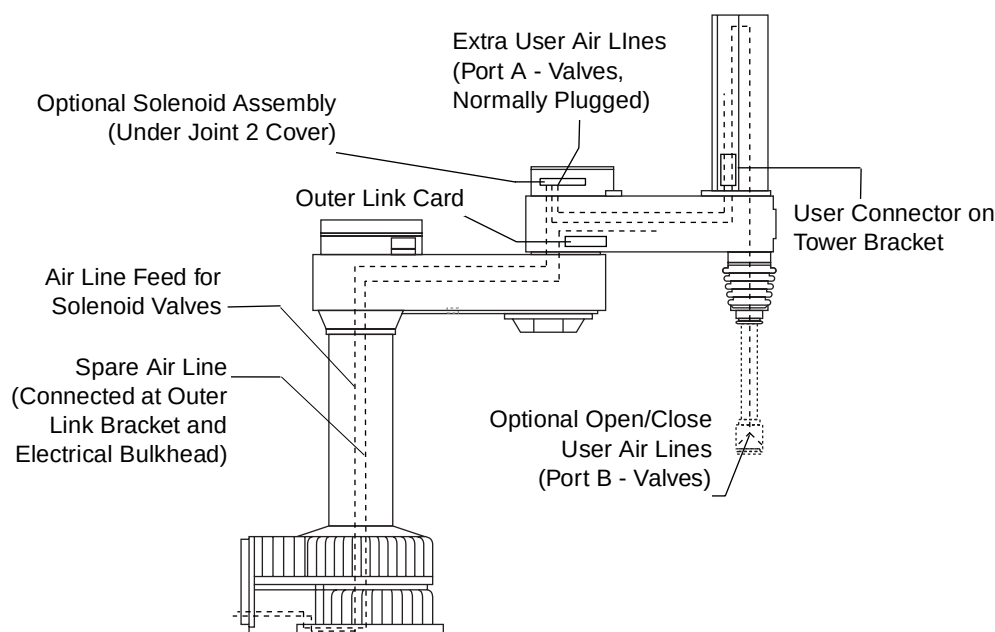


**Figure 7-7. User Connections in the Adept-XL Robot**

## Gripper Solenoid Drivers

The 24 VDC IC drivers are located on a PC board under the joint 1 cover. Each driver is designed to handle a 24 VDC solenoid or motor at a nominal 75 mA each. The total current drawn from all four drivers must not exceed 300 mA. If you do not use the Adept solenoid valve option, you may connect to these drivers using a 9-pin D-Sub male connector. See Table 7-4 for the connector pins and signal names and Figure 7-5 for location of the connector.

**Table 7-4. Pin Assignment on 9-Pin Connector J240 for Gripper Solenoid Signals**

| Pin Number | Signal Name                  |
|------------|------------------------------|
| 1          | Sig 3001 (24 VDC, 75 mA max) |
| 6          | Common                       |
| 2          | Sig 3002 (24 VDC, 75 mA max) |
| 7          | Common                       |
| 4          | Sig 3003 (24 VDC, 75 mA max) |
| 9          | Common                       |
| 3          | Sig 3004 (24 VDC, 75 mA max) |
| 8          | Common                       |
| 5          | Not used                     |

## **7.4 Adept-XL Robot Camera Bracket Kit**

### **Introduction**

The Adept-XL Robot Camera Bracket Kit, P/N 95000-00100, provides a convenient way of mounting cameras to the outer link of the robot. The kit consists of the following:

- Two camera plates
- Two camera brackets
- One camera mount slide bracket
- One camera mount channel
- M4 X 12 mm screws
- M4 stainless steel flat washers
- M5 X 12 mm screws

### **Tools Required**

- M4 Allen wrench
- M3 Allen wrench

### **Installation Time**

Approximately 10 minutes.

### **Procedure**

Install the two camera plates to the outer link with two M5 X 12 mm screws (see Figure 7-8 on page 150 as you perform this procedure).

Install the two camera brackets to the two camera plates with two stainless steel washers and two M4 X 12 mm screws.

Mount the camera channel to the camera brackets with M4 x 12 mm screws.

Mount the camera to the camera mount.

Mount the camera and camera mount to the camera channel using M5 x 12 mm screws.

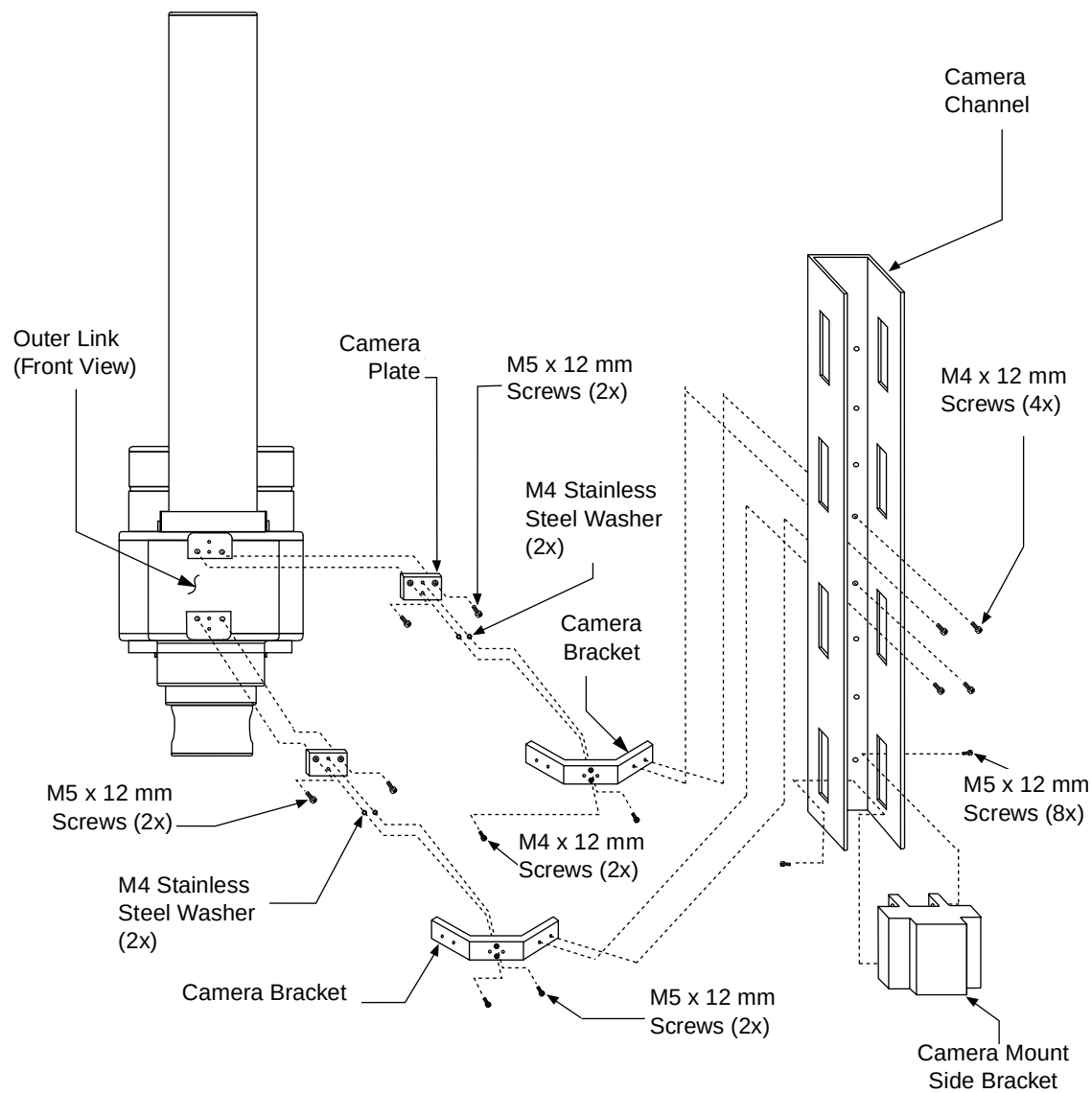


**Figure 7-8. Adept-XL Robot Camera Mounting Bracket**

## 7.5 Mounting User Equipment on the Robot Arm

Figure 7-9 and Figure 7-10 show the locations on the inner and outer link covers where user equipment may be mounted.

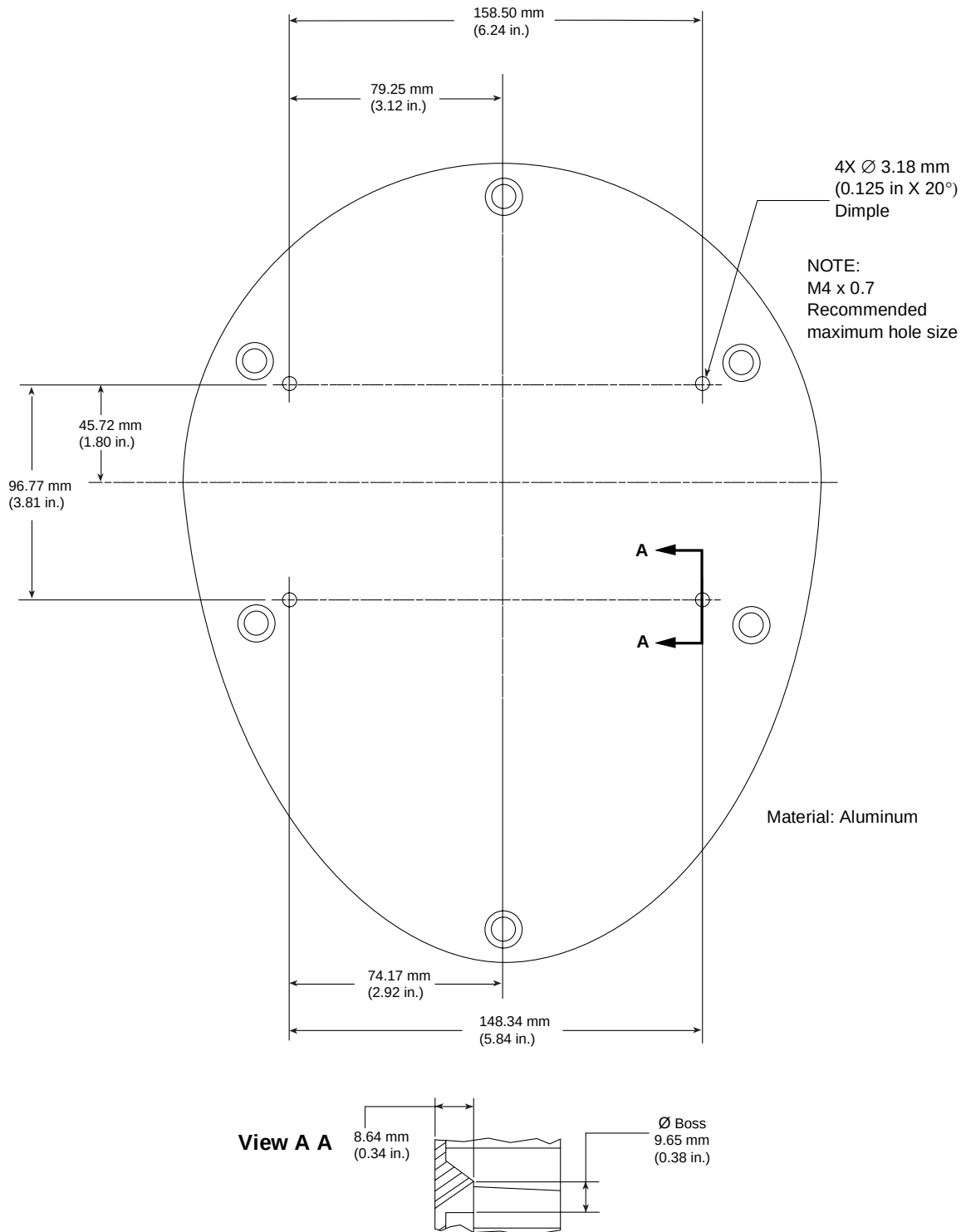


Figure 7-9. J1 Access Cover Mounting Locations for Tooling

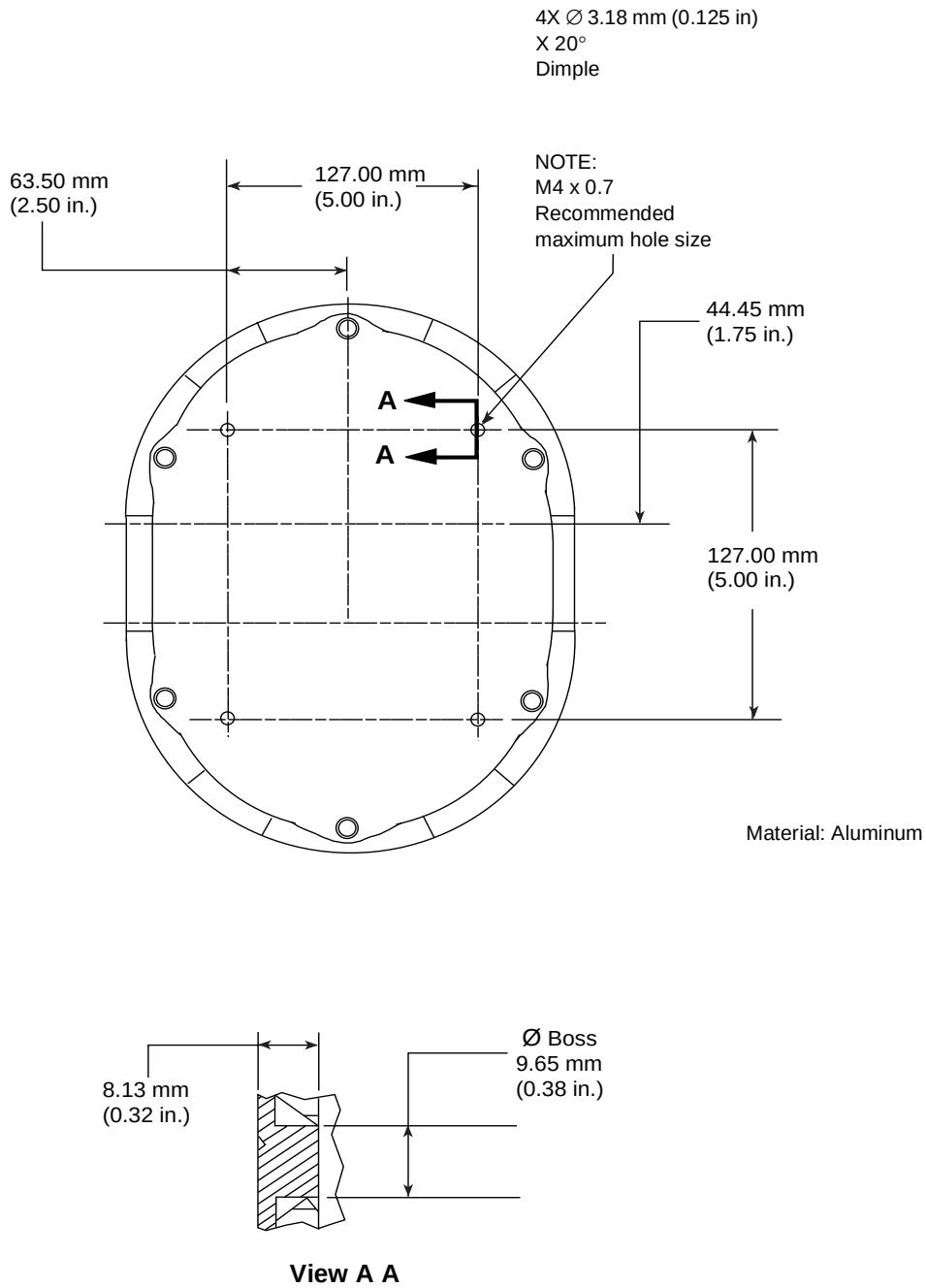


Figure 7-10. J2 Upper Cover Mounting Locations for Tooling

## 7.6 Installing End-Effectors on an Adept-XL Robot

The user is responsible for providing and installing any end-effector or other end-of-arm tooling. End-effectors can be attached to the user flange using either four M6 screws or a ring clamp, which are supplied in the accessories kit.

An M6 x 12 mm dowel pin is also supplied in the accessories kit. This dowel pin fits in the through hole in the user flange and can be used as a keying or antirotation device in a user-designed end-effector.

If hazardous voltages are present at the end-effector, you should install a ground connection from the base of the robot to the end-effector. See Figure 4-20 on page 94. Also see Figure 11-6 on page 247 for dimensions of the user flange.

### Calculating Payload Inertia

The V<sup>+</sup> program instruction GAIN.SET allows you to optimize the servo gain settings for various payloads. If you intend to use GAIN.SET (see V<sup>+</sup> *Language Reference Guide*) for the purpose of gain scheduling, you will need to calculate the inertias for each payload configuration.

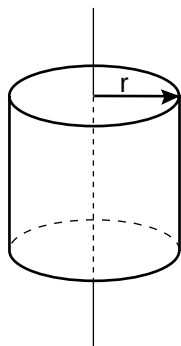
In order to select an appropriate value for the servo gain set number, you must know the approximate inertia of your payload. This is the inertia of the load about an axis that passes through the centerline of the robot quill. The inertia should be calculated in kg-cm<sup>2</sup>.

The inertia of any payload can be modeled as the sum of the inertias contributed by individual elements of the gripper and part. That is, by the formula:

$$\text{Total Inertia} = \text{Inertia of Gripper} + \text{Inertia of Parts}$$

In most cases approximations can be made. For example, if the mass of the parts carried by the gripper far exceeds the mass of the gripper, then you may choose to ignore the inertia contributed by the gripper itself. Note that the inertia of a given mass increases significantly as its distance from the center of the quill increases.

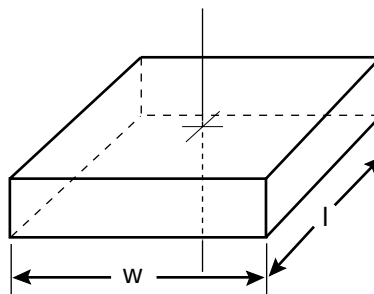
Inertias for the commonly used shapes of a cylinder and rectangular bar are given by the following:



Cylindrical Payload Inertia =

$$(1/2) m * r^2$$

(m = mass in kilograms,  
r = radius in centimeters)



Rectangular Payload Inertia =

$$(m/12) (l^2 + w^2)$$

(m = mass in kilograms,  
l = length in centimeters,  
w = width in centimeters)

The formulas for the inertia for other common shapes, as well as the formula for an off-axis mass, can be found in many mechanical engineering textbooks.

## Adept-XL Initial Payload and GAIN.SET Tuning Values for Joint 4

**Table 7-5. AdeptOne-XL Initial Payload and GAIN.SET Tuning Values for Joint 4**

| Joint 4 Inertia                                                | GAIN.SET Value | Payload Value |
|----------------------------------------------------------------|----------------|---------------|
| 0-880 kg-cm <sup>2</sup><br>(0-300 lb-in <sup>2</sup> )        | 0 (default)    | 14 (default)  |
| 881-2053 kg-cm <sup>2</sup><br>(301-700 lb-in <sup>2</sup> )   | 1              | 46            |
| 2054-3188 kg-cm <sup>2</sup><br>(701-1087 lb-in <sup>2</sup> ) | 2              | 82            |
| Example:      GAIN.SET 2,2<br>PAYLOAD 50,4                     |                |               |

**Table 7-6. AdeptThree-XL Initial Payload and GAIN.SET Tuning Values for Joint 4**

| <b>J4 Inertia</b>                                                  | <b>GAIN.SET Value</b> | <b>Payload Value</b> |
|--------------------------------------------------------------------|-----------------------|----------------------|
| 0-2933 kg-cm <sup>2</sup><br>(0-1000 lb-in <sup>2</sup> )          | 0 (default)           | 10 (default)         |
| 0-880 kg-cm <sup>2</sup><br>(0-300 lb-in <sup>2</sup> )            | 1                     | 3                    |
| 881-2933 kg-cm <sup>2</sup><br>(301-1000 lb-in <sup>2</sup> )      | 2                     | 13                   |
| 2934-5865 kg-cm <sup>2</sup><br>(1001-2000 lb-in <sup>2</sup> )    | 3                     | 30                   |
| 5866-10264 kg-cm <sup>2</sup><br>(2001-3500 lb-in <sup>2</sup> )   | 4                     | 55                   |
| 102650-14663 kg-cm <sup>2</sup><br>(3500-5000 lb-in <sup>2</sup> ) | 5                     | 85                   |

## 7.7 DeviceNet Communication Link

DeviceNet is a communications link that connects industrial I/O devices to a message packeting network. All devices connect to the same backbone cable, eliminating the need for individual wiring for each I/O point.

Adept incorporates the following DeviceNet ready hardware in the Adept-XL robot:

- Female connector for the robot tower; Micro-style 12 mm thread DIN female connector (see Figure 7-11 on page 157)
- Male Micro-style 12 mm thread DIN connector at the robot base.
- A nonstandard DeviceNet cable consisting of two shielded twisted pairs that connect the above connectors. Adept considers this cabling to be a drop line with a maximum total length of 6 meters and therefore uses the following wire sizes:

| Wire         | Adept | DeviceNet<br>"thin cable" |
|--------------|-------|---------------------------|
| Power pairs  | 24    | 22                        |
| Signal pairs | 28    | 24                        |

This means that total current on the power pairs must be limited to 2A instead of the standard 3A in a DeviceNet trunk line. Because this is intended to be a DeviceNet "drop line" with a maximum of 6 meters (16.5 feet), the full data rate should be achievable. However, Adept has only tested the internal cable at 125k baud.

See *Adept MV Controller User's Guide* for physical installation. See the *Instructions for Adept Utilities Program* for software setup.

### Recommended Vendors for Mating Cables and Connectors

A variety of vendors have molded cable assemblies for the "Micro-style" connector including **Brad Harrison**, **Crouse Hinds**, **Lumberg**, **Turk**, and others. In addition, **Hirshmann**, **Phoenix Contact**, and **Beckhoff** have mating micro connectors which have screw terminals in the plug to allow the user to make custom cables.

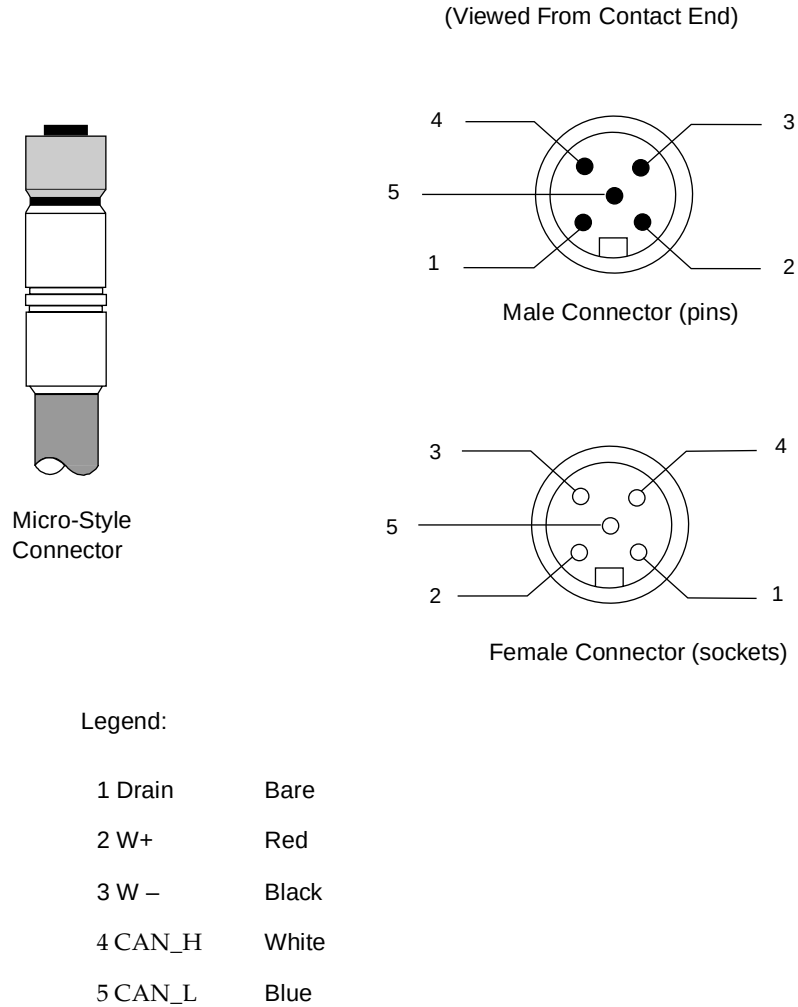


Figure 7-11. Micro-Style Connector Pinouts

## 7.8 Ethernet Connections

The Ethernet connector is a shielded RJ45 receptacle (see Figure 7-13 on page 159 for the location of the Ethernet connection). See the *AdeptNet User's Guide* for details on TCP/IP, FTP, and NFS capabilities. Adept strongly recommends the use of shielded twisted pair cables to eliminate interferences from motor, amplifier, and other sources of electromagnetic radiation. Ethernet packet transmissions can be greatly impaired when shielded cable is not used.

## 7.9 Connecting User Supplied Serial Communications Equipment

### RS-232 (JCOM) Connector

There is one RS-232 serial port (JCOM) for general-purpose serial I/O functions on the CIP (see Figure 4-10 on page 78 for the location of the JCOM connector). This serial port is referred to as device LOCAL:SERIAL:4. This serial port can be accessed by any AWC board configured to run V<sup>+</sup>. The connector is a 9-pin DB-9 male receptacle. The signal and pin information are shown in Table 7-7.

See the V<sup>+</sup> *Language User's Guide* for information on serial I/O. See the *Instructions for Adept Utility Programs* for setting the default serial port configuration using the CONFIG \_C program. The serial port on the CIP can be configured for use at up to 38,400 bps.

**Table 7-7. JCOM Connector Pin Assignments**

| Pin | Signal             | Pin | Signal   |
|-----|--------------------|-----|----------|
| 1   | Not used           | 6   | Not used |
| 2   | RXD                | 7   | Not used |
| 3   | TXD                | 8   | Not used |
| 4   | Not Used           | 9   | Not used |
| 5   | SG (Signal Ground) |     |          |

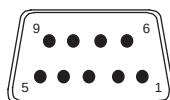


**Figure 7-12. JCOM Pin Locations**

**NOTE:** The serial port on the CIP does not provide hardware handshaking signals.

### AdeptWindows Controller (AWC) Board Serial I/O Ports

The AdeptWindows Controller (AWC) board has three serial I/O connectors, two RS-232 and one RS-422/485 port (see Figure 7-13). Systems using a programmer's terminal (ASCII) connect through the RS-232/Term port on the AWC board.

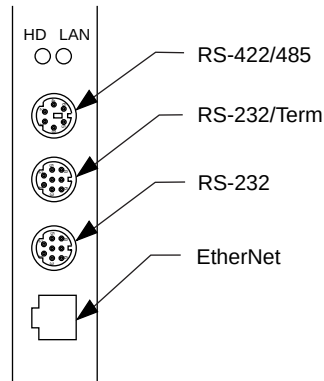


**Figure 7-13. AWC User Communication Connectors**

#### Serial Port 2 (RS-232)

This connector is identical to the RS-232/Term connector. This connector can be used for general serial communication but not for connecting any user-supplied terminals. This port is designated LOCAL.SERIAL:3.

To configure the port speed and other communications parameters, use the CONFIG\_C utility program, the V<sup>+</sup> FSET program instruction, or the FSET monitor command.

**Table 7-8. RS-232/Term Connector Pin Assignments**

| Pin | Signal | Type   |
|-----|--------|--------|
| 1   | DTR    | Output |
| 2   | CTS    | Input  |
| 3   | TXD    | Output |
| 4   | GND    | Ground |
| 5   | RXD    | Input  |
| 6   | RTS    | Output |
| 7   | DCD    | Input  |
| 8   | GND    | Ground |

**RS-422/485 Connector**

The RS-422/485 connector is a 6-pin circular mini DIN female connector (see Figure 7-13 on page 159). The pin assignment are shown in Table 7-9. RS-422/485 is a point-to-point protocol for connecting to a single destination. This port can also be configured as a multi-drop port (RS-485).

To change the configuration of the RS-422/485 port, use the CONFIG\_C utility program or the V<sup>+</sup> FSET program instruction. This port is designated LOCAL.SERIAL:1

**Table 7-9. RS-422/485 Connector Pin Assignments**

| Pin | Signal | Type   |
|-----|--------|--------|
| 1   | GND    | Ground |
| 2   | GND    | Ground |
| 3   | TXD-   | Output |
| 4   | RXD+   | Input  |
| 5   | TXD+   | Output |
| 6   | RXD-   | Input  |

**The SIO Board Serial Ports**

If your system includes an SIO board, there are three additional serial ports that can be accessed by any AWC board configured to run V<sup>+</sup>. See the *Adept MV Controller User's Guide* for details.

## 7.10 Connecting Customer-Supplied Safety and Power Control Equipment to the CIP

The connection of the customer-supplied safety and power control equipment to the CIP is through the JUSER connector. This connector is a 37-pin female D-sub connector located on the side panel of the CIP. Refer to Table 7-10 and Table 7-11 for the JUSER pin-out explanations. See Figure 7-14 and Figure 7-15 for the wiring diagram

**NOTE:** If you have the MMSP option you can make most of the safety and power connections to the Security Panel. See Chapter 5 for details.

**Table 7-10. Contacts Provided by the JUSER Connector**

| Pin Pairs                                      | Description                                                                       | Comments                                                                   | Shorted if NOT Used |
|------------------------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------|---------------------|
| <b>Voltage-Free Contacts Provided by User</b>  |                                                                                   |                                                                            |                     |
| 1,20                                           | Remote High Power on/off momentary PB                                             | used to enable High Power                                                  | No                  |
| 4,23                                           | User E-Stop CH 1 (mushroom PB, safety gates, remote MCP E-stop, etc.)             | N/C contacts                                                               | Yes                 |
| 5,24                                           | User E-Stop CH 2 (same as pins 4 and 23)                                          | N/C contacts                                                               | Yes                 |
| 6,25                                           | Remote ENABLE (hold-to-run)                                                       | N/O contacts (make to enable). Use for Remote MCP                          | Yes                 |
| 7,26                                           | Remote ENABLE (hold-to-run)                                                       | N/O contacts (make to enable). Use for Remote MCP                          | Yes                 |
| 8,27                                           | Muted Safety Gate CH 1 (causes E-Stop in AUTOMATIC mode only)                     | N/C contacts                                                               | Yes                 |
| 9,28                                           | Muted Safety Gate CH 2 (same as pins 8 and 27)                                    | N/C contacts                                                               | Yes                 |
| 10,29                                          | Remote MANUAL/AUTOMATIC switch CH 1. MANUAL = Open<br>AUTOMATIC = Closed          | CIP's MANUAL/AUTOMATIC switch must be in AUTOMATIC mode                    | Yes                 |
| 11,30                                          | Remote MANUAL/AUTOMATIC switch CH 2. MANUAL = Open<br>AUTOMATIC = Closed          | CIP's MANUAL/AUTOMATIC switch must be in AUTOMATIC mode                    | Yes                 |
| <b>Voltage-Free Contacts Provided by Adept</b> |                                                                                   |                                                                            |                     |
| 12,31                                          | System Power Switch Contacts. Use with external relay circuit to turn on AC Power | Mainly used to turn on MV-5/10 AC power with System Power switch on CIP    |                     |
| 13,32                                          | E-Stop indication CH 1                                                            | Contacts are closed when CIP, MCP, and user E-Stops are <i>not</i> tripped |                     |
| 14,33                                          | E-stop Indication CH 2 (same as pins 13 and 32)                                   | Contacts are closed when CIP, MCP, and user E-stops are <i>not</i> tripped |                     |

**Table 7-10. Contacts Provided by the JUSER Connector** (Continued)

| Pin Pairs                       | Description                                                    | Comments                                                                                                               | Shorted if NOT Used |
|---------------------------------|----------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|---------------------|
| 15,34                           | MANUAL/AUTO indication CH 1                                    | Contacts are closed in AUTOMATIC mode                                                                                  |                     |
| 16,35                           | MANUAL/AUTO indication CH 1                                    | Contacts are closed in AUTOMATIC mode                                                                                  |                     |
| <b>Nonvoltage-Free Contacts</b> |                                                                |                                                                                                                        |                     |
| 2,21                            | Adept-Supplied 5 VDC and GND for High Power On/Off Switch Lamp | Use with Remote High Power On/Off switch above.<br><br>See "Remote High Power Control" on page 167 for current limits. |                     |
| 3,22                            | User-Supplied 24 VDC for Central Control High Power on/off     | Active only in AUTO and REMOTE (NET=1) modes                                                                           |                     |

**Table 7-11. Remote MCP Connections on the JUSER Connector**

| Pin JUSER     | Pin MCP | Description                   |
|---------------|---------|-------------------------------|
| 37            | 1,9     | Logic GND                     |
| 17            | 3       | MCP TXD                       |
| 18            | 2       | MCP RXD                       |
| 19            | 5       | +12 VDC (max 350mA)           |
| 36            | 8       | -12 VDC (max 50mA)            |
| 4,23 (Note 1) | 6,7     | MCP E-Stop PB CH 1            |
| 5,24 (Note 2) | 11,12   | MCP E-Stop PB CH 2            |
| 6,25 (Note 2) | 13,15   | MCP Enable CH 1 (Hold-to-run) |
| 7,26 (Note 2) | 14,16   | MCP Enable CH 2 (Hold-to-run) |

Note 1: Must be used in User E-Stop circuit.

Note 2: Must be used in User Enable circuit.

**NOTE:** There is an E-Stop loop on the robot outerlink that may be useful in wiring E-Stop switches to end-of-arm tooling (for example, to detect a break-away gripper). Information on the "AmpLoop" emergency stop circuitry is available from the FAXBack number listed in "How Can I Get Help?" on page 41.

## JUSER 37-pin D-sub Controller Interface Panel E-Stop and MANUAL/AUTO Controls

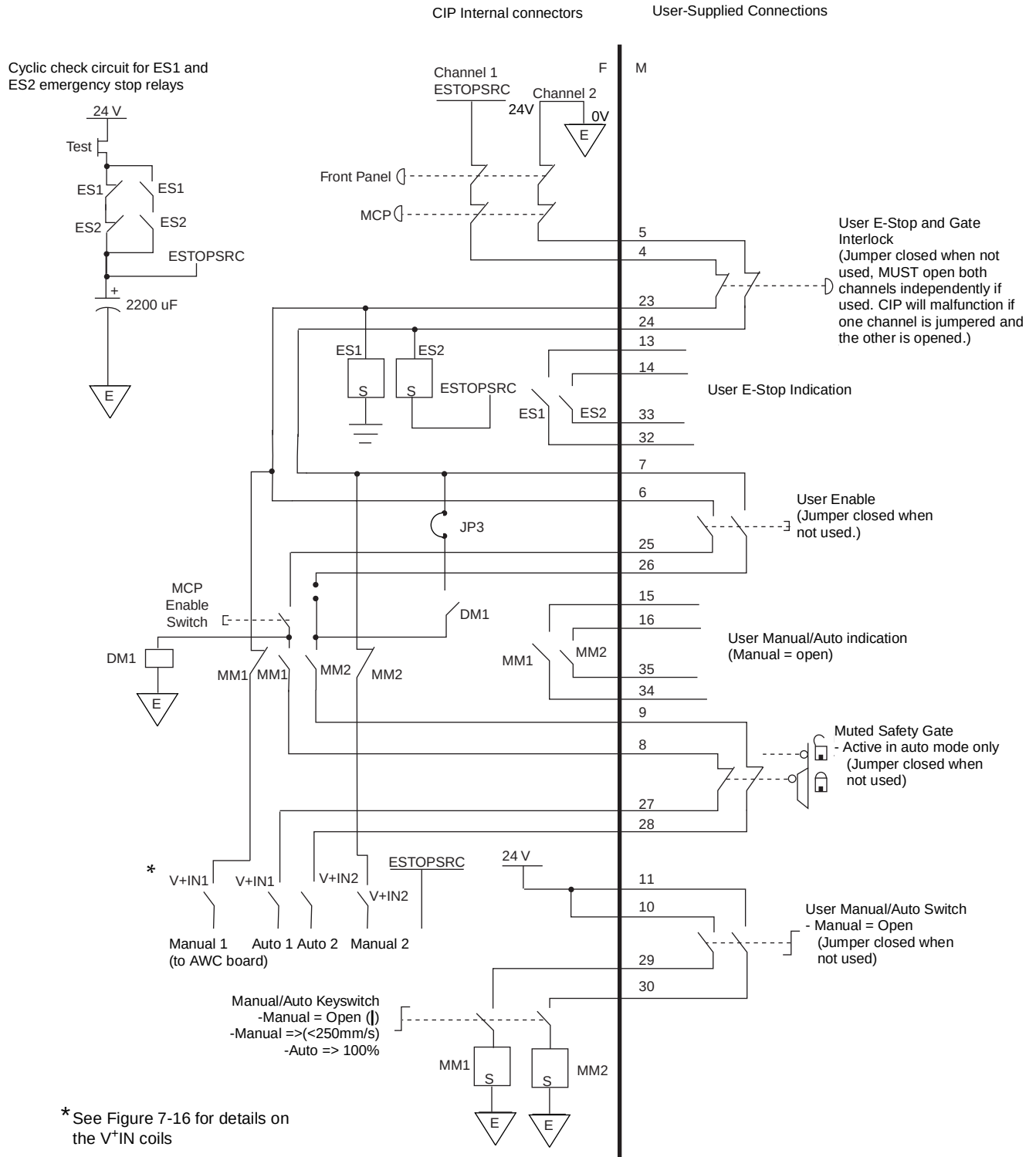


Figure 7-14. JUSER 37 Pin D-sub Connector

## J-User 37-pin D-sub Controller Interface Panel Remote Connections

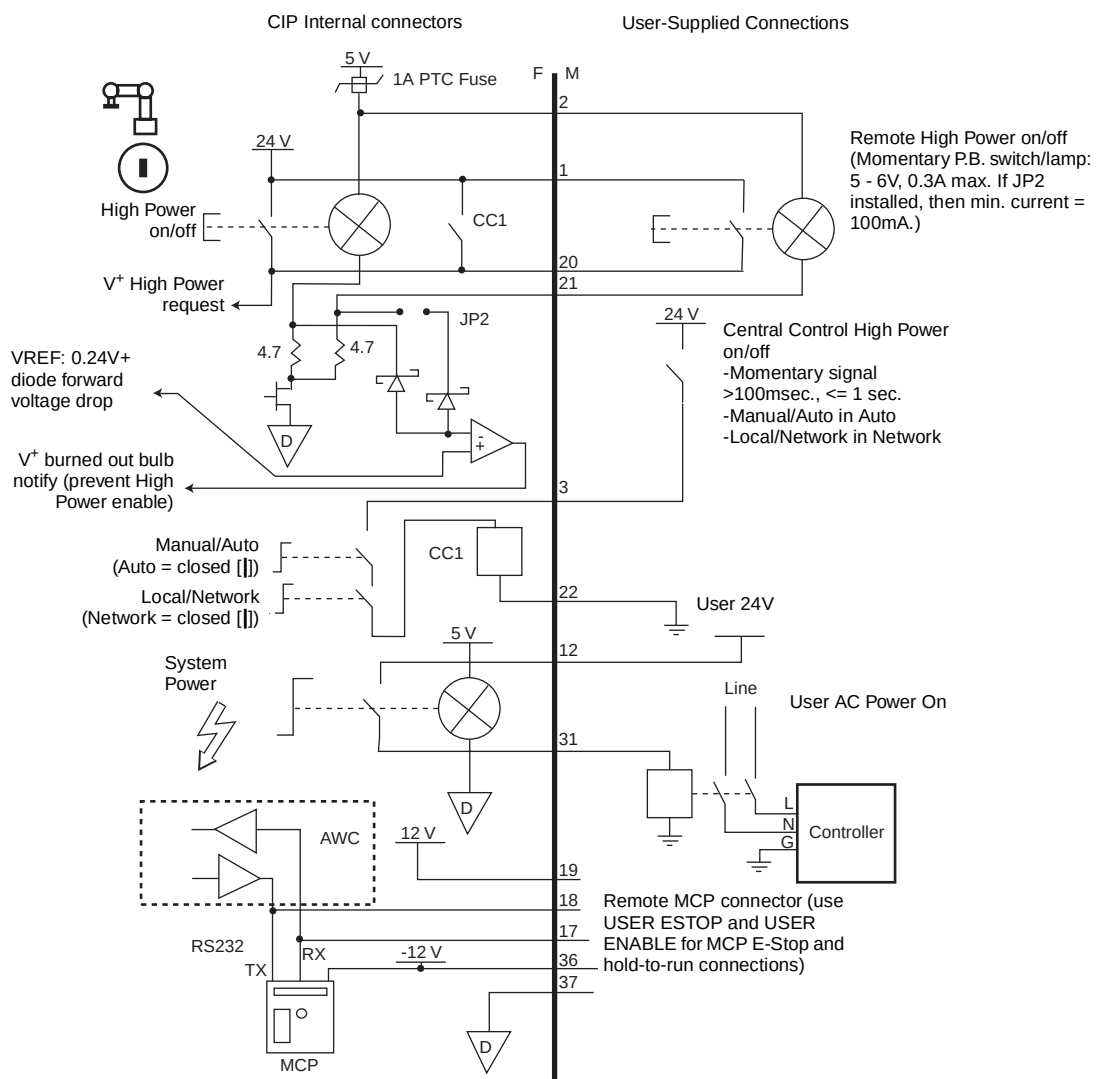


Figure 7-15. J-User 37 Pin D-sub Connector

## JSIO 50-pin D-sub

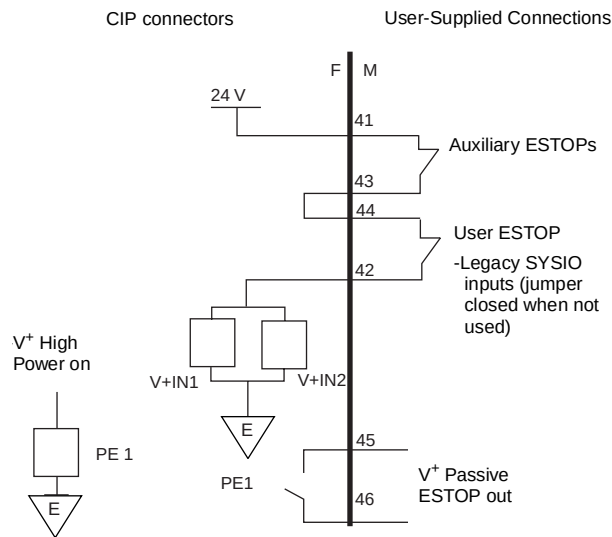


**Figure 7-16. JSIO Emergency Stop Circuit**

### Emergency Stop Circuit

The CIP provides two methods for user-supplied emergency stop circuits. This gives the AWC system the ability to duplicate E-Stop functionality from a remote location using voltage-free contacts. Both the JUSER connector and the JSIO connector provide external E-Stop connections into the CIP.

The JUSER connector has a two-channel E-Stop input on pins 4 to 23 and 5 to 24.

The JSIO connector provides a single channel E-Stop that controls two relays in the CIP. This E-Stop is for compatibility with legacy applications using the 50-pin connector on the SIO board. These JSIO pins are 41 to 43 and 42 to 44 (see Figure 7-14, Figure 7-15, Figure 7-16, and Table 7-10 for the customer E-Stop circuitry). The two required connections will be arranged in series.

**NOTE:** These pins must be shorted if not used. Both channels must open independently if used. Although an E-Stop will occur, the CIP will malfunction if one channel is jumpered closed and the other channel is opened. It also will malfunction if the channels are shorted together.

### Remote Sensing of CIP, MCP, and User E-Stop Push Button Switches

A method has been provided to indicate the status of the E-Stop chain, inclusive of the CIP E-Stop push button, the MCP E-Stop push button, and the user emergency stop contacts.

**NOTE:** These contacts do not indicate the status of any contacts below the User E-Stop contacts. Thus, they will not indicate the MCP ENABLE contacts or the Manual mode teach restrict sensor contacts.

Two pairs of pins on the JUSER connector (pins 13,32 and 14,33) provide voltage-free contacts, one for each channel, to indicate whether the E-Stop chain, as described above, on that channel is closed. Both switches are closed on each of the redundant circuits in normal condition (no E-Stop). You may use these contacts to generate an E-Stop for other equipment in the workcell. The load on the contacts should not exceed 40 VDC or 30 VAC at a maximum of 1A.

These voltage-free contacts are provided by a redundant, cyclically checked, positive-drive, safety relay circuit for EN-954-1 Category 3 operation (see Figure 7-14, Figure 7-15, and Table 7-10 for the customer emergency stop circuitry).

### Muted Safety Gate E-Stop Circuitry



**WARNING:** The Adept XL series of robots are Category 3 robots and they require a Category 3 E-Stop on all workcell guarding if a teach-restrict interface such as the MMSP option is not installed. The muted safety gate functionality is not compatible with a Category 3 E-Stop and must not be used on systems that do not include the MMSP option. To use the muted safety gate function with the MMSP option, see Chapter 5.

### JSIO E-Stop Circuitry

Six pins provide two single-channel E-Stop inputs and a single-channel output. The output relay contact, Passive E-Stop Output, is different from the E-Stop outputs described above. This contact closes only when High Power is on, not when the E-Stop circuit is closed.



**CAUTION:** These are single channel contacts and are not suitable for EN-954-1 Category 3 operation.

The two pairs of pins on the JSIO connector (pins 41, 42 and 43, 44) provide connections for user and auxiliary emergency stop circuitry (see Figure 7-14, Table 7-10, and Table 7-11 for the customer emergency stop circuitry).

**NOTE:** These pins must be jumpered closed if not used.

The High Power On contacts and JSIO connector pins 45 and 46 are called the “Passive E-Stop Output” because they are compatible with older Adept equipment. The load on the contacts should not exceed:

Maximum Voltage 40 VDC, 30 VAC  
Maximum Current 1A

### Category 3 E-Stop

If your system does not include the MMSP option, it must be protected by a Category 3 dual-channel, cross-checked interlocked barrier system. The system must disconnect the AC power supply to the PA-4 power chassis if any person enters the workcell. See “Risk Assessment – Category 1” on page 34.

## Remote Manual Mode Control

The CIP also provides a connection for a user-supplied Manual Mode circuit (see Figure 7-14, Figure 7-16, Table 7-10, and Table 7-11 for the customer Manual Mode circuitry).

This circuitry must be incorporated into the robot workcell to provide a “Single Point of Control” (the operator) when the controller is placed in Manual mode. Certain workcell devices, such as PLCs or conveyors, may need to be turned off when the operating mode switch is set to Manual mode. This is to ensure that the robot controller does not receive commands from devices other than from the MCP, the single point of control.

The two channel Manual/ Automatic Mode select circuit is designed to fail to the highest safety condition. If either channel is open, the controller will be in Manual mode. This requires that the User Remote Manual Mode Control electrical contacts be in series with the contacts on the CIP Auto/Manual mode selector switch. To select Automatic mode, *both* the Remote Manual Mode Control and the CIP Auto/Manual Switch must be in Automatic mode (both switches must be closed).

The CIP provides connections for a remote user panel circuitry that allows a second user panel at another location (see Figure 7-14, Figure 7-15, Table 7-10, and Table 7-11 for the customer remote user panel circuitry).

Two separate inputs on the JUSER connector (10,29 and 11,30) provide connections for remote MANUAL/AUTOMATIC functionality.

- MANUAL = Open
- AUTOMATIC = Close

**NOTE:** These pins must be jumpered if not used.

Two pairs of pins on the JUSER connector (pins 15, 34 and 16, 35) provide a voltage-free contact to indicate whether the CIP and/or remote AUTOMATIC/MANUAL switches are closed. The customer may use these contacts to control other mechanisms (e.g., conveyor, linear modules, etc.) when MANUAL mode is selected. The load on the contacts should not exceed 40 VDC or 30 VAC at a maximum of 1A.

## Remote High Power Control

The CIP also provides a connection for an additional user-supplied High Power enable circuit (see Figure 7-14, Figure 7-15, Figure 7-16, Table 7-10, and Table 7-11 for the customer High Power circuitry). The CIP has two different methods of remote operation of the High Power push button located on the CIP. These connections are optional.

The first method allows relocating the push button switch to a more convenient location. The second allows the start-up of multiple robots from a central control computer that can communicate with the robot controllers. Implementation of either method must conform to EN standard recommendation.

The European standard, EN 775, Ind. Robots, Part 6, Recommendations for Safety: Item 7.2.5 Emergency Stop, reads: “Each robot system operator station shall have a readily accessible emergency stop device. The manual intervention and reset procedure to restart the robot system after an emergency stop shall take place outside the restricted space”.

Thus, it is important that the remote High Power push button be located outside of the protected space of the robot.

Pins 1 and 20, 2 and 21, and 3 and 22 of the JUSER connector provide this remote capability. The first two circuits allow the duplication of the CIP High Power push button/lamp with no difference in operation. Pins 2 and 21 provide power for the lamp, +5 VDC and ground, respectively. Pins 1 and 20 are inputs for voltage-free N/O contacts from a user-supplied momentary push button switch.

The user-supplied remote High Power switch drives a relay in the CIP. The contact of the relay generates a  $V^+$  High Power request signal, which is used internally. The electrical characteristics are as follow:

- **Coil:** 24 VDC at 1440  $\Omega$ , including a parallel “flyback” diode.
- **Timing:** the High Power signal transition will be seen only if the signal is off at least 32 milliseconds followed by on for at least 32 milliseconds. After a positive transition, there must be no positive transitions for at least 2 seconds before another positive transition will be recognized.

### Remote High Power On/Off Lamp

The CIP High Power On/Off Lamp will cause a  $V^+$  error if the lamp burns out. This error prevents High Power from being turned on. This safety feature prevents a user from not realizing that High Power is enabled because the High Power indicator is burned out.

This feature can be added to the remote High Power lamp as well. A jumper must be installed on JP2 inside the CIP. See “Changing the Lamp on the CIP High Power Enable Switch” on page 230 for details on accessing the JP2 jumper. The remote High Power lamp current limitations are:

Maximum current, 300 mA at 5V.

Minimum current, 100 mA if JP2 is installed. Otherwise, there is no minimum current.

The third pair of pins, which provides for more restricted operation, complying with the EN 775 recommendation, will prevent the use of the “Central Control High Power On/Off” when the system is in Manual Mode. This function will work only when the keyswitches on the CIP are in the following positions:

- Operating keyswitch is in the Automatic Mode
- Network keyswitch is in the (I) position

The user-supplied voltage to provide a “Central Control High Power On/Off” function drives a relay in the CIP with the following electrical characteristics:

- **Coil:** 24 VDC at 1440  $\Omega$ , including a parallel “flyback” diode.
- **Timing:** the High Power signal transition will be seen only if the signal is off at least 32 milliseconds followed by on for at least 32 milliseconds. After a positive transition, there must be no positive transitions for at least 2 seconds before another positive transition will be recognized.

## Connecting the System Power Switch to the CIP

The CIP also provides a connection for a user-supplied system power circuit (see Figure 7-14, Figure 7-15, Table 7-10, and Table 7-11 for the customer system power switch circuitry).

The CIP includes support for turning on and off system power to the controller. If you use this switch, you must provide an AC contactor with the following electrical characteristics:

- 12V or 24V, AC or DC coil, limited to less than 500 mA

The user connection for system power is at the JUSER connector (pins 6 and 24). You will need to provide a power supply to match the coil voltage of the external contactor.

In addition, the system power switch has a second pole that is wired through the 25-pin cable to the Manual Mode Safety Package. Access to this pole is at TB5, pins 5 and 6, on the E-Stop PCA of the MMSP. You can wire to whichever contact is more convenient.

See Figure 7-17 for details on wiring through the CIP. See Figure 7-18 for details on wiring through the Security Panel.

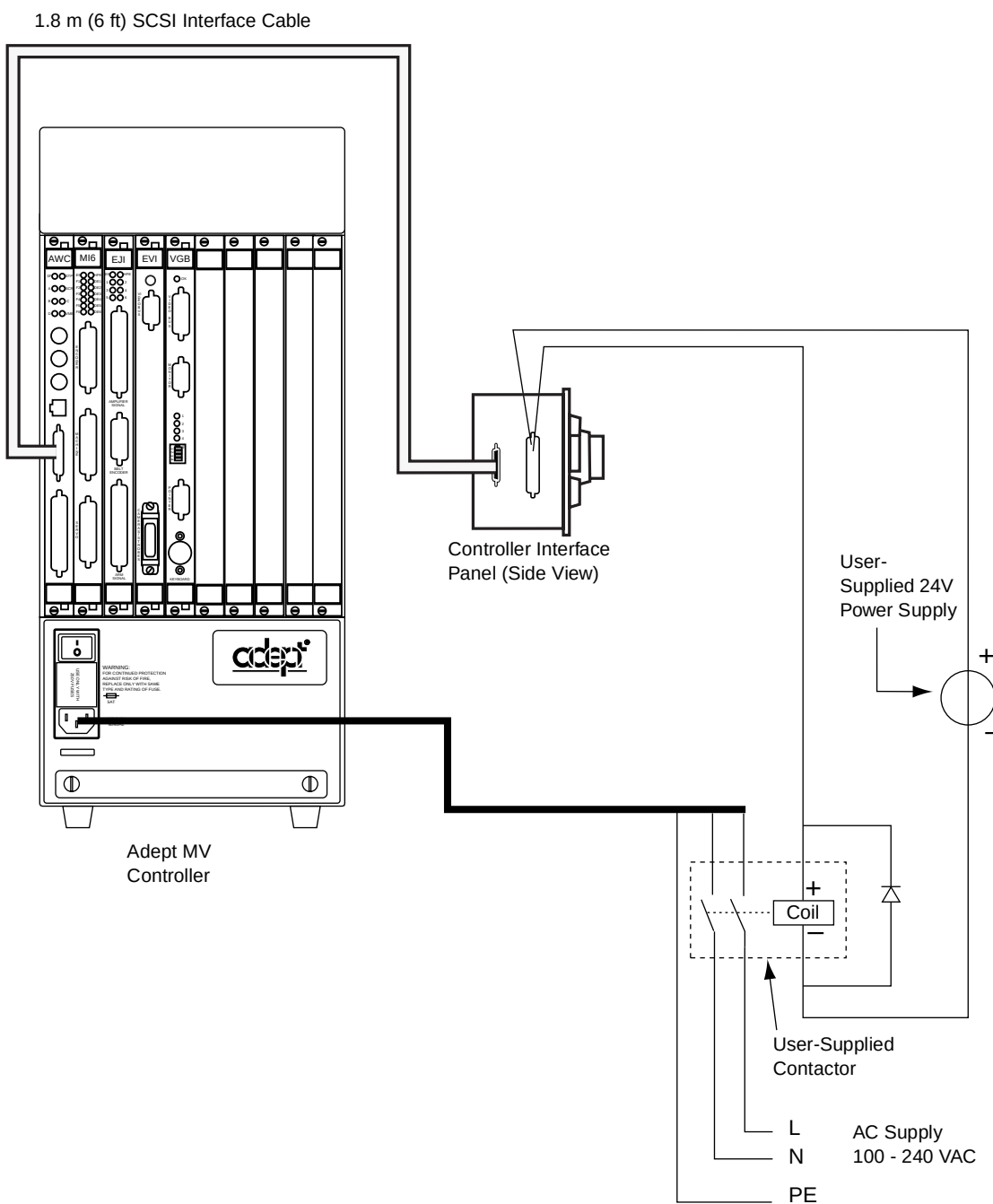


Figure 7-17. System Power Switch Circuit

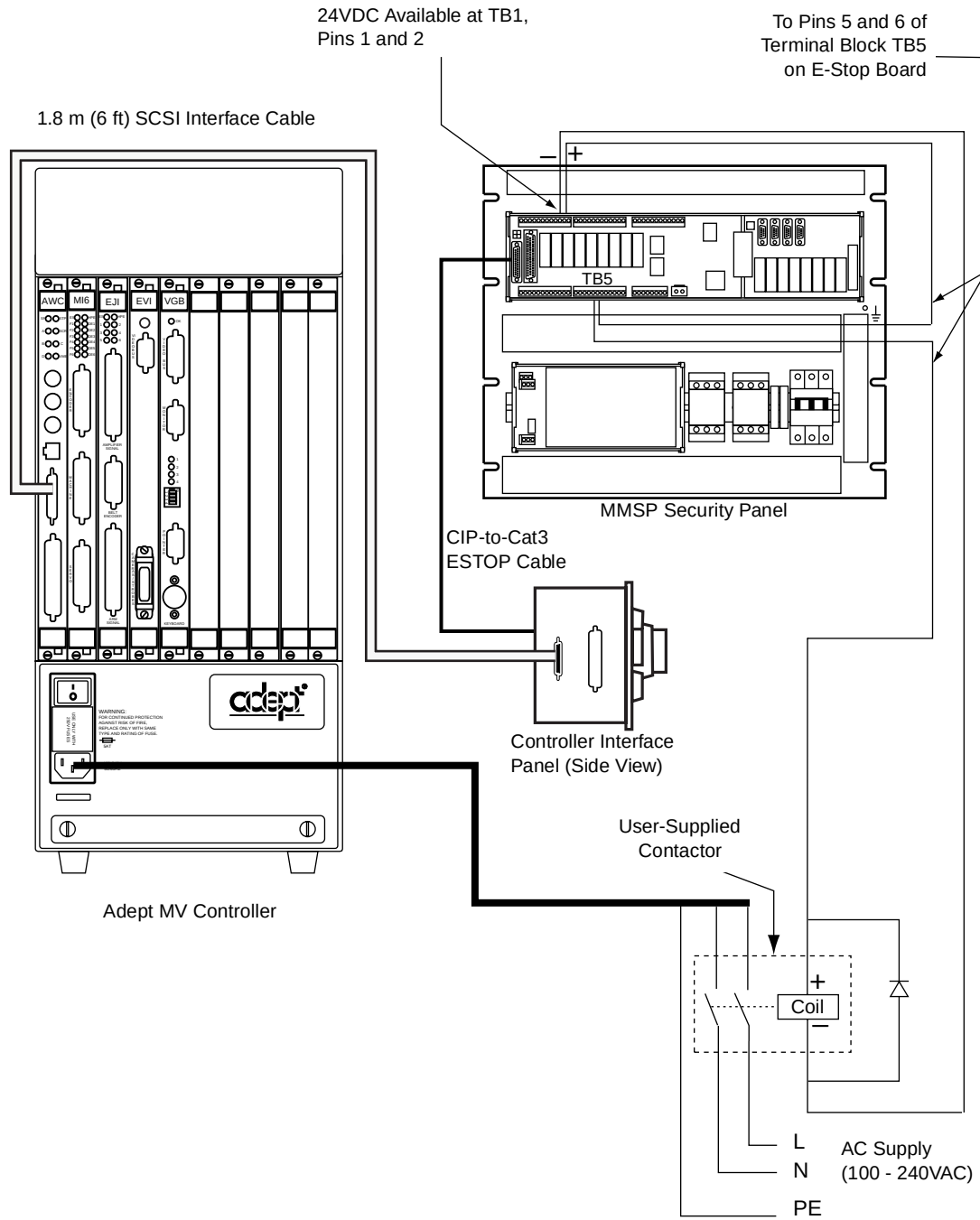


Figure 7-18. System Power Switch Circuit (MMSP Option)

## Manual Mode Safety Package (MMSP) Connector

The CIP also provides a connection for a user-supplied MMSP circuit (see Figure 7-14, Figure 7-15, Table 7-10, and Table 7-11 for the customer MMSP circuitry).

## Remote User Panel Connections

The CIP provides connections for a remote user panel circuitry that allows a second user panel at another location (see Figure 7-14, Figure 7-15, Table 7-10, and Table 7-11 for the customer remote user panel circuitry).

## Remote MCP Connections

For the following remote MCP connections see Figure 7-14 and Figure 7-15, and refer to Table 7-10 and Table 7-11 for the customer remote MCP circuitry.

**NOTE:** If a remote MCP connection has been added through the JUSER connector, the optional MCP bypass plug (P/N 10335-01060) must be installed in the MCP connector on the CIP.

### Remote E-Stop Circuit

When using a remote connector for the MCP, the MCP E-Stop push button contacts (red mushroom switch) must be wired in series with any other E-Stop contacts on the “USERESTOP CH1”(pins 4 and 23) and “USERESTOP CH2” (pins 5 and 24).

### Remote Enable Switch Connections

Two pairs of pins on the JUSER connector (pins 6, 25 and 7, 26) provide connection for an MCP enable switch (momentary push button). This input duplicates the functionality of the MCP Enable switch on MCP. Electrically, the enable switch is wired in series with the MCP enable switch connections on the CIP. If the MCP is connected remotely using the remote MCP connection on the JUSER connector, wire the MCP enable switch of the MCP to these pins.

**NOTE:** These pins must be shorted if not used.

**NOTE:** The MCP III uses only one switch channel for the Enable function. (The MCP E-Stop button uses two channels.) The MCP Enable switches E-Stop channel 1 directly while channel 2 is switched by a sense relay (DM1 in Figure 7-14).

This means that only channel 1 of the remote Enable switch is active! Please contact Adept for custom modifications of the MCP III or MCP bypass plug if you need a two-channel MCP enable function.

## 7.11 Connecting User-Supplied Digital I/O Equipment

There are two sets of digital I/O connections on the CIP. The JSIO connector accesses the first set, a group of 12 inputs and 8 outputs. The signals are numbered 1001 through 1012 for the inputs and 1 through 8 for the outputs<sup>1</sup>. In the JSIO group, all the signals have independent source and ground connections. This group of inputs contains the four high-speed inputs that are used by the system for interrupts and latching. The outputs, although independent, have a lower current rating of only 100mA compared to 700mA for the extended outputs (described in the next section).

The second group of digital I/O connections, or extended DIO, uses four connectors: 32 inputs on JDIO1 and JDIO2 and 32 outputs on JDIO3 and JDIO4. The signals are numbered 1033 through 1064 for the inputs and 33 through 64 for the outputs. The extended DIO are arranged in groups of eight signals with a common ground connection for each group and a common source for each output group. However, the groups are independent of each other and do not share sources or grounds. The electrical characteristics of the inputs are similar to the JSIO signals, but the outputs have a higher voltage rating (30 VDC vs. 24 VDC) and a higher current rating than the JSIO outputs. See the *Adept MV Controller User's Guide* for details on wiring extended DIO signals. See the *V<sup>+</sup> Language User's Guide* for information on digital I/O programming.

### JSIO Connector

The JSIO connector on the CIP is a 50-pin, standard density D-Sub female connector (see Figure 4-10 on page 78 for location). There are 12 inputs and 8 outputs, each optically isolated from the circuitry of the CIP. The connector also provides access to a single channel emergency stop circuit (E-Stop input and Passive E-Stop output). To access this connector, a user-supplied cable with a 50-pin male, D-Sub connector at one end is required. Note that with the MMSP option, input signal 1012 and output signals 1 thru 5 are not available. The remaining I/O signal lines are available on terminal blocks at the MMSP. See Table 5-8, "DIO Input Specifications for TB1 and TB2 on the Security Panel," on page 121 and Table 5-10, "DIO Output Specifications for TB3," on page 123.

**Input Signals** The JSIO connector handles input signals 1001 to 1012. (On systems with the MMSP option, input channel 1012 is used by the MMSP and is not available for users.) Each channel has an input and a corresponding return line. See Table 7-12 for input specifications. The connector pinouts are shown in Table 7-14.

**Table 7-12. DIO Input Circuit Specifications (JSIO Connector)**

|                           |                  |
|---------------------------|------------------|
| Operational voltage range | 0 to 24 VDC      |
| "Off" state voltage range | 0 to 3 VDC       |
| "On" state voltage range  | 10 to 24 VDC     |
| Typical threshold voltage | $V_{in} = 8$ VDC |
| Operational current range | 0 to 6 mA        |
| "Off" state current range | 0 to 0.5 mA      |

<sup>1</sup> These signals are also available at the Security Panel on systems with the MMSP option. See Table 5-8, "DIO Input Specifications for TB1 and TB2 on the Security Panel," on page 121.

**Table 7-12. DIO Input Circuit Specifications (JSIO Connector)** (Continued)

|                                   |                                                     |
|-----------------------------------|-----------------------------------------------------|
| "On" state current range          | 2 to 6 mA                                           |
| Typical threshold current         | 2.5 mA                                              |
| Impedance ( $V_{in}/I_{in}$ )     | 3.9 K $\Omega$ minimum                              |
| Current at $V_{in} = +24$ VDC     | $I_{in} \leq 6$ mA                                  |
| Turn on response time (hardware)  | 5 $\mu$ sec maximum                                 |
| Software scan rate/response time  | 16 ms scan cycle/<br>32 ms max latency <sup>a</sup> |
| Turn off response time (hardware) | 5 $\mu$ sec maximum                                 |
| Software scan rate/response time  | 16 ms scan cycle/<br>32 ms max latency              |

<sup>a</sup> See "Fast Input Signals 1001 to 1004" below for exceptions.

**NOTE:** The input current specifications are provided for reference; voltage sources are typically used to drive the inputs.

In Figure 7-19 on page 175, example 1 shows inputs (1001 to 1004) with a negative common, example 2 shows inputs (1005 to 1008) with a positive common, and example 3 shows inputs (1009 to 1012) with an independent power supply (no common).

**NOTE:** These are examples. Any of the three methods can be used on any channel.

### REACT Input Signals 1001 to 1012

Inputs 1001 to 1012 (only) may be used by the  $V^+$  REACT and REACTI instructions. See the *V<sup>+</sup> Language Reference Guide* for information on these instructions. If you are going to use these instructions, you should plan your digital I/O channel usage accordingly. (Inputs on the optional DIO board or CIP JDIOx connectors cannot be used by the REACT and REACTI instructions.)

### Fast Input Signals 1001 to 1004

In addition to functioning as normal input signals, signals 1001 to 1004 can have the following special uses:

- Fast DIO  $V^+$  interrupt events (INT.EVENT)
- Robot and encoder position latch
- Vision trigger

**NOTE:** When the program task priorities are properly set, there is a 2 ms maximum latency for fast inputs 1001 to 1004 when used with  $V^+$  INT.EVENT instruction (requires the optional  $V^+$  Extensions License). See the *V<sup>+</sup> Language Reference Guide* for a description of the INT.EVENT instruction.

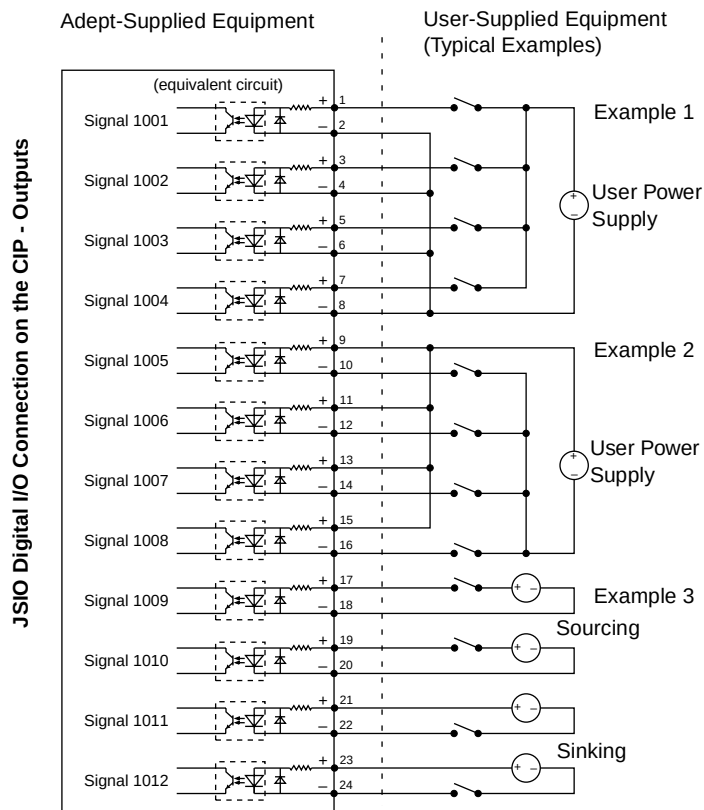


**Figure 7-19. Digital Input Wiring Examples (JSIO Connector)**

### Output Signals

The JSIO connector handles output signals 0001 to 0008. On systems with the MMSP, output channels 0006 to 0008 are used by the MMSP and are not available for users. Refer to Table 7-13 for output specifications. The locations of the signals on the connector are shown in Table 7-14. The JSIO connector provides separate positive and negative connections for each channel (no internal common connections). This allows the choice of wiring for current-sourcing or current-sinking modes.

**Table 7-13. DIO Output Specifications (JSIO Connector)**

|                                            |                                                                                   |
|--------------------------------------------|-----------------------------------------------------------------------------------|
| Operating voltage range                    | 0 to 24 VDC                                                                       |
| Operational current range, per channel     | $I_{out} \leq 100 \text{ mA}$ , short-circuit protected                           |
| $V_{drop}$ across output in "on" condition | $V_{drop} \leq 2.7 \text{ V}$ at 100 mA<br>$V_{drop} \leq 2.0 \text{ V}$ at 10 mA |
| Output off leakage current                 | $I_{out} \leq 600 \mu\text{A}$                                                    |
| Turn on response time (hardware)           | 3 $\mu\text{sec}$ maximum                                                         |
| Software scan rate/response time           | 16 ms scan cycle/ 32 ms max response time                                         |
| Turn off response time (hardware)          | 200 $\mu\text{sec}$ maximum                                                       |
| Software scan rate/response time           | 16 ms scan cycle/ 32 ms max response time                                         |

The following drawing shows two examples of different connections to the digital outputs on the JSIO connector. The examples are negative common and positive common.

Example 1: outputs 0001 to 0004 are shown with positive common.

Example 2: outputs 0005 to 0008 are shown with negative common.

**NOTE:** These are examples. Either method can be used, in any combination, on any channel.

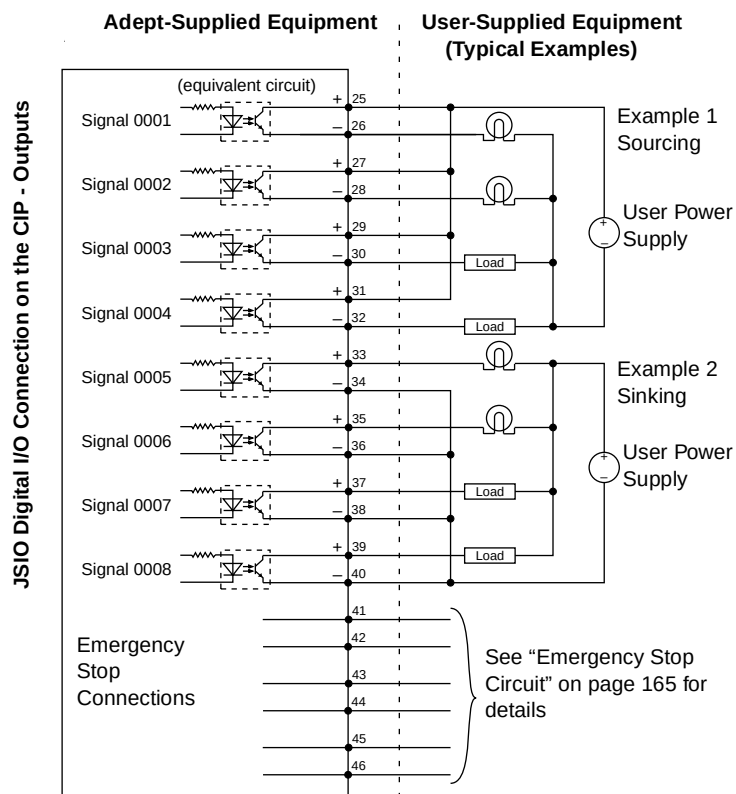


Figure 7-20. Digital Output Wiring for JSIO Connector

Table 7-14. JSIO Digital I/O Connector Pin Assignments

| Pin | Signal Name  | Pin | Signal       | Pin             | Signal                   | Pin             | Signal                  |
|-----|--------------|-----|--------------|-----------------|--------------------------|-----------------|-------------------------|
| 1   | Input 1001   | 2   | 1001 return  | 27              | Output 0002+             | 28              | Output 0002–            |
| 3   | Input 1002   | 4   | 1002 return  | 29              | Output 0003+             | 30              | Output 0003–            |
| 5   | Input 1003   | 6   | 1003 return  | 31              | Output 0004+             | 32              | Output 0004–            |
| 7   | Input 1004   | 8   | 1004 return  | 33              | Output 0005+             | 34              | Output 0005–            |
| 9   | Input 1005   | 10  | 1005 return  | 35              | Output 0006+             | 36              | Output 0006–            |
| 11  | Input 1006   | 12  | 1006 return  | 37              | Output 0007+             | 38              | Output 0007–            |
| 13  | Input 1007   | 14  | 1007 return  | 39              | Output 0008+             | 40              | Output 0008–            |
| 15  | Input 1008   | 16  | 1008 return  | 41 <sup>a</sup> | Auxiliary E-Stop input+  | 42 <sup>a</sup> | External E-Stop input–  |
| 17  | Input 1009   | 18  | 1009 return  | 43 <sup>a</sup> | Auxiliary E-Stop input – | 44 <sup>a</sup> | External E-Stop input + |
| 19  | Input 1010   | 20  | 1010 return  | 45              | Passive E-Stop output+   | 46              | Passive E-Stop output–  |
| 21  | Input 1011   | 22  | 1011 return  | 47              | Not used                 | 48              | Not used                |
| 23  | Input 1012   | 24  | 1012 return  | 49              | Not used                 | 50              | Not used                |
| 25  | Output 0001+ | 26  | Output 0001– |                 |                          |                 |                         |

<sup>a</sup> Pins 41, 42, 43, and 44: See Figure 7-16 on page 165 for more information.

## 7.12 Extended Digital I/O Signals

The extended digital I/O signals are 64 optically isolated digital I/O channels (32 input and 32 output). They are wired to connectors JDIO1 through JDIO4, which are located on the back of the CIP (see Figure 4-10). The electrical specifications for the inputs are similar to the JSIO inputs but have a different wiring configuration. In addition, they may not be used for REACTI programming, high-speed interrupts, or vision triggers. The outputs have a higher current carrying capacity than the JSIO. See the *Adept MV Controller User's Guide* for details on using extended digital I/O.

**NOTE:** The signals on the JDIOx connectors can be superseded by a DIO board that is installed and addressed as DIO board #1. To use both the JDIOx signals and DIO boards, address the first DIO board as DIO board #2. See the *Adept MV Controller User's Guide* for details on DIO boards.



# Verifying the System Installation

# 8

Verifying that the system is correctly installed and that all safety equipment is working correctly is a three-step process. This chapter covers the first two steps. Step one covers starting the control system for the first time and verifying that all components have been correctly installed. Once the safe initialization of the control system has been verified, the second step (referred to as “commissioning the system”) is to verify that all safety equipment is working properly. The last step is to verify that the robot moves correctly. The Manual Control Pendant is used for this step and is covered in Chapter 9.



**WARNING:** After installing the robot, you must test it before you use it for the first time. Failure to do this could cause death or serious injury or equipment damage.

## 8.1 Installation Check List

Before using the robot, make the following checks to ensure that the robot and controller have been properly installed.

### Mechanical Checks

- Verify that the robot is mounted level and that all fasteners are properly installed and tightened.
- Verify that any end-of-arm tooling is properly installed.
- Verify that all other peripheral equipment is properly installed and in a state where it is safe to turn on power to the robot system.

### AC Power to the Adept Components Checks

Verify that the Adept MV controller and the Adept PA-4 power chassis are correctly connected to their AC power supplies.

1. Make sure that AC power is shut off to both the Adept MV controller and the PA-4 power chassis.
2. Verify that the three-phase AC power (180-264 VAC for 4-wire, 380 VAC for 5-wire) is connected to the Adept PA-4 power chassis (or the optional MMSP security panel if it is installed).
3. Verify that the single phase AC power (180-264 VAC) is connected to the Adept MV controller.

4. If the System Power On/Off switch on the CIP is used, check the connections to this switch.
5. Verify that all voltages and voltage frequencies are within range (see section 2.4 on page 48).

## Board and Cable Installation Checks

Make sure that all the boards in the Adept PA-4 power chassis and Adept MV controller are secured and the connection cables are correctly installed.

1. Secure all boards and blank front panels to the Adept MV controller chassis. Tighten both the top and bottom mounting screws on each front panel. This ensures proper grounding of the controller from an EMC standpoint and ensures good connection to the controller backplane.
2. Secure all amplifier modules and blanking plates on the Adept PA-4 power chassis. Tighten both the top and bottom mounting screws on each front panel. This ensures proper grounding of the amplifier controller subsystems from an EMC standpoint and ensures good connection to the drawer connectors at the rear of the chassis. The drawer connectors carry power and interlock signals from/into the power chassis from the amplifiers.

**NOTE:** There is a safety interlock built into the Adept PA-4 power chassis that prevents power from being applied if the amplifier modules are not correctly screwed into place.

3. Secure the cable connections from the EJI board to the amplifiers in the Adept PA-4 power chassis. Tighten the screws on the D-sub connectors on the EJI-to-Amp cable assembly.
4. Tighten the screws on the cable connections from the EJI board and other motion boards to the mechanisms to ensure integrity of signal connections, especially encoder feedback, and to ensure integrity of shields and other EMC measures.
5. Tighten the screws on the cable connections from the amplifiers to the mechanisms to ensure integrity of power connections and to ensure integrity of safety grounds and shields.
6. Secure the cable connection between the AWC and CIP. Verify that the plug is latched on both ends of the cable.
7. If you are using the AdeptWindows PC user interface, connect a shielded Ethernet cable from the hub (or server) to the shielded RJ45 connector on the AWC board. Unshielded cables will degrade the integrity of the AdeptWindows PC link, particularly when power is applied to the robot or mechanism. Use “straight” cables to a hub or a “crossover” cable to a stand-alone PC.

### Cable Connection Summary (All Systems)

Check to make sure all the following cables are correctly installed:

- Robot to power chassis (Arm Power Cable)
- CIP to MCP (install bypass plug if not used)
- CIP (JAWC) to AWC board

- Robot to controller (Arm Signal Cable)
- Controller to power chassis (EJI-to-Amp Cable)
- JUSER to user-supplied equipment (install jumper plug if not used)

### **Cable Connection Summary (MMSP Systems)**

Check to make sure all the following cables are correctly installed:

- Robot to Security Panel
- Controller to Security Panel
- Power chassis to Security Panel
- CIP (JMMSP) to Security Panel

### **User-Supplied Safety Equipment on JUSER and JSIO Connector Checks**

Check the following safety equipment connected to the JUSER and JSIO connectors on the CIP:

1. There are eight pairs of contacts that must be connected on the JUSER connector (see Table 7-10, “Contacts Provided by the JUSER Connector,” on page 161) to ensure proper continuity of the emergency stop circuitry. Verify that these connections are secure and reliable and that a redundant pair of contacts is installed, one for each E-Stop channel. Double check that the state of the contacts on each pair matches and the contacts are closed. Each contact is separately connected to its respective E-Stop channel. Inadvertent connection between the E-Stop channels will short the E-Stop power supply, making it impossible to apply High Power.
2. There are two pairs of contacts in the JSIO connector that must be connected to ensure proper continuity of the emergency stop circuitry. Verify that these connections are secure, reliable, and closed prior to enabling power.
3. Make sure that guarding around the workcell is properly connected to either the Muted Safety gate inputs on the JUSER connector or, if appropriate, to the User E-Stop connections on the JUSER connector. Make sure that all gate, E-Stop push button switches, and other interlocks have two independent electrical poles. Make sure that a pair of redundant contacts is installed and that these contacts are separately connected to their respective E-Stop channels. Make sure that all interlock or emergency stop devices are wired in series (not in parallel) before connecting to the User E-Stop connections. Identify all wiring with Channel 1 or Channel 2. Inadvertent connection between the channels will short the E-Stop power supply, making it impossible to apply High Power.
4. Make sure that workcell components have been properly interlocked to avoid hazards when the robot/motion system is operated in Manual Mode. (Per “ISO 10218 Manipulating Robots Safety”, the robot control system must employ a “single point of control” when operated in Manual Mode.)

### **E-Stop Button and Switch Checks**

1. Verify that the red E-Stop push buttons on the CIP, MCP, and User Panel (if installed) are in the normal, unlatched (electrically closed) position.

2. Verify that the MCP is mounted on a rack that holds the MCP Enable switch in the ON position.
3. Verify that the user panel enable contacts are closed, that a pair of redundant contacts is installed and that these contacts are separately connected to their respective E-Stop channels. Inadvertent connection between the channels will short the E-Stop power supply, making it impossible to apply High Power to the robot.

## 8.2 Applying Power to the Adept Control System

After you have made the checks listed above you are ready to turn on system power.



**WARNING:** All safety systems must be in place and operating before applying power to the system. Extra care should be taken during the initial tests of the robot system.

1. Turn the AC power switches on the Adept MV controller and PA-4 power chassis to the ON (I) position.
2. Turn the System Power switch on the CIP, if used, to the ON (I) position.
3. The AWC will execute its boot sequence. When the boot sequence has completed, the SF/OK LED should be green. If this LED is red, the AWC has not booted properly. Turn off power to the controller and reboot. If the problem persists, call Adept Customer Service. Note the state of the LEDs marked 1 to 3, which indicate the problems shown in Table 8-1.
4. The other LEDs should be off. If the ES (E-Stop) LED on the AWC board is flickering red, this could result from:
  - a. AWC systems may occasionally oscillate after the software has tested the E-Stop channels. If this occurs, toggle (press and release) the E-Stop push button on the CIP. The E-Stop LED should now be off (unless there are other problems in the E-Stop circuitry).
  - b. The oscillation may also be the result of a mismatch between the contacts forming a “pair of contacts” in the two E-Stop channels. Perhaps on one channel, the user E-Stop contacts are closed, and on the other they are open. Check each pair of contacts to make sure that they match and that they are all closed per Table 7-10, “Contacts Provided by the JUSER Connector,” on page 161.
  - c. Also, a short between the two E-Stop channels may sometimes result in this oscillating red ES LED. If the problem persists, call Adept Customer Service.
5. If the E-Stop LED is continuously red, then at least one pair of E-Stop contacts is open or the E-Stop contacts on the JSIO connector are open. Review the checklist items above to resolve the problem. If the problem persists, call Adept Customer Service.

### LED Status Indicators on the AWC

The LEDs on the front of the AWC indicate the following conditions:

O = off    G = green    R = red

**Table 8-1. LED Status Indicators**

| LED Display | Error # | Description                                                                |
|-------------|---------|----------------------------------------------------------------------------|
| O-O-O       | 0       | No error                                                                   |
| O-O-R       | 1       | System clock is dead or too fast. Clock interrupts are not being received. |
| O-R-O       | 2       | Hardware configuration error. Address switches/SYSCTL wrong                |
| O-R-R       | 3       | Graphics board failure. VGB not responding                                 |
| R-O-O       | 4       | Memory test failure. Free storage error                                    |
| R-R-O       | 6       | Software serial I/O configuration error                                    |
| G-O-O       | C       | Uninitialized trap                                                         |
| G-O-G       | D       | Bus error detected                                                         |

If the AWC displays any of the above errors, contact Adept Customer Service (see “How Can I Get Help?” on page 41).

## 8.3 Checks After Applying Power

1. Verify that High Power can be enabled:
  - a. Enter the following command at the monitor window:  
 ENABLE POWER  
 Or press the COMP/PWR button on the MCP
  - b. When the High Power push button/light on the CIP begins flashing, press and hold the push button for 1 - 2 seconds. When you release the push button, the light should remain lit continuously indicating that High Power has successfully been enabled.
  - c. If the light does not stay on, the High Power enable process has failed and a message will be displayed on the monitor and MCP indicating why.
2. Verify that all E-Stop devices are functional (MCP, CIP, and user supplied). Test each mushroom button, safety gate, light curtain, etc., by enabling High Power and opening the safety device. The High Power push button/light on the CIP should go out and the red ES LED on the AWC should be lit.

## 8.4 Using the SAFE\_UTL Program (MMSP Only)

Before an MMSP-equipped system can be used, the Adept utility program SAFE\_UTL must be run to verify that the MMSP safety equipment is running properly.

Category 3 systems contain several components to ensure safety when the robot is operating in Manual mode. Some components should be tested at the time of commissioning. These components should also be tested every six months.

Adept provides the SAFE\_UTL Utility Program to test these components. This section gives instructions for using SAFE\_UTL and describes the tests required to commission the robot. Additional tests should be performed periodically. These tests are also described in this section.

### Category 3 Robot Components

#### Accelerometer

An accelerometer is located in the outer link of the robot to prevent excessive acceleration of joints 1 and 2 while operating in Manual mode. If the accelerometer is tripped, the emergency stop circuit is opened, causing High Power to be disabled.

#### B+ Amplifier Voltage Restrict

Circuitry in the B+ amplifier measures the voltage applied to the joint 3 and 4 motors. If the voltage exceeds a preset limit, the emergency stop circuit is opened, causing High Power to be disabled. This will prevent excessive speed and acceleration while operating in Manual mode.

#### CIP Switches and Buttons

After the user requests that High Power be enabled, the High Power lamp flashes. Before High Power is turned on, this button must be pressed. If the button is not pressed within 10 seconds<sup>1</sup>, it will stop flashing and High Power will not be turned on. Tests are also performed on the key switches.

#### MCP Enabling Switch

The Enabling switch on the Manual Control Pendant must be pressed for High Power to remain on (see Figure 9-1 on page 199 for the location of the MCP Enabling switch). If the Enabling switch is released, High Power is disabled. If the MANUAL/AUTO key switch is in the manual position, the Enabling switch must be cycled before High Power will be enabled. This is to confirm, before enabling High Power, that the Enabling switch is operational. The following instructions are displayed on the system monitor:

```
Release then press the MCP Enable  button.  
Press the HIGH POWER button when it blinks.
```

The Manual Control Pendant displays the following messages:

```
Release then press the MCP Enable  button.  
Press the HIGH POWER button to enable power.
```

---

<sup>1</sup> The time-out value can be changed using the CONFIG\_C utility.

To enable High Power, release and then press the Enable switch. The High Power push button/lamp will begin flashing. Press and hold the High Power push button for 1 - 2 seconds and High Power will be enabled.

You will perform the above procedure several times while running SAFE\_UTL.

### Dual Brake Solenoid Valves

Two brake solenoids are used to release the robot brakes. If one solenoid fails by sticking open, the brakes will still engage. If one solenoid fails by sticking closed, the brakes cannot be released. These components were tested at the factory and do not need to be tested at the time of commissioning. Both solenoid valves, however, must be tested periodically thereafter. See “Tests Performed Periodically” on page 193.

### Robot Brakes

Brakes are in place to prevent robot motion when High Power is off, and to stop the robot during an Emergency Stop. The Adept-XL brakes can be manually released by pressing the brake release button located on the joint 1 inner link. Brakes are used on joints 1, 2, 3, and 4.

## 8.5 SAFE\_UTL.V2

Adept provides the SAFE\_UTL.V2 file in the \UTIL\ subdirectory on the controller hard disk (drive C or D). This utility must be used to test the Category 3 robot components during the commissioning procedure. It is also used to test the components periodically. If you do not have the MMSP option on your robot, you can skip the rest of this chapter and go to Chapter 9.



**WARNING:** These tests must be performed only by skilled or instructed persons.

### Commissioned vs. Not Commissioned

As shipped from Adept the system is marked as “not commissioned”, meaning the Category 3 components must be tested prior to system operation. (The brake solenoids and dump valves have been tested at the factory.) Prior to operating the robot in the Manual mode, the system must be marked as “commissioned”. The system is marked as “commissioned” only after the SAFE\_UTL utility is executed and all tests pass.

If any of the tests fail, carefully note any messages and then repeat the test. If the failure persists, contact Adept Customer Service.

**NOTE:** Testing all Category 3 components requires approximately 40 minutes.

Attempting to enable High Power (on a system marked as “not commissioned”) while the MANUAL/AUTO key switch is in the manual position will produce the following error message:

\*User has not tested Cat 3 system\*  
\*Switch can't be enabled\*

## Starting the SAFE\_UTL Utility

To perform the necessary tests, the SAFE\_UTL utility must be run. Follow the steps below to load and execute the program:

1. Remove all end-effectors from the quill flange.
2. Load the utility program into system memory with the command:<sup>1</sup>  
`LOAD c:\util\safe_utl.v2`
3. Start execution of the program with the command:  
`EXECUTE 1 a.safe_utl`

The following menu is displayed:

```
*** Adept MMSP Test Programs (Version 13.0) ***
Copyright (c) 1996-1998 by Adept Technology, Inc.
```

### Language Selection

```
0 => EXIT
1 => English
2 => Deutsch
3 => Francaise
4 => Italiano
```

Enter Selection:

After a language selection is made, the following is displayed:

```
Warning: All personnel should be outside the safety
barrier. All safety gates should be installed and closed.
```

```
Note: Adept recommends that all end-of-arm tooling be
removed from the robot prior to testing. Some tests may
require a second person.
```

## 8.6 Tests Performed at Time of Commissioning

---

**NOTE:** There are no tools required for these tests.

**NOTE:** Some actual display screens may vary slightly from the displays shown in this handbook.

The utility program displays the following menu and prompts the user to select an option:

---

<sup>1</sup> The SAFE\_UTL programs can be loaded from the D: drive, from the A: drive, or from a remotely mounted NFS drive by substituting the correct drive letter and path.

\*\*\* Adept MMSP Test Programs (Version 13.0) \*\*\*  
 Copyright (c) 1996-1998 by Adept Technology, Inc.

Robot 1: xxx-xxxx \*Not Commissioned\*

```

0 => EXIT
1 => Commissioning Tests
2 => Accelerometer
3 => B+ Amp Voltage Restrict
4 => CIP Switches and Buttons
5 => MCP E-STOP Functions
6 => Brake Holding Force
7 => Accelerometer Diagnostic
8 => B+ Amp Diagnostic
9 => CIP Diagnostic

```

Enter Selection:

In order to mark the robot as “commissioned”, option 1 must be selected. Adept strongly recommends, however, that the individual options be tested first, starting with option 2. This will allow you, the operator, to become familiar with the tests and procedures before attempting to commission the robot. The other options can also be selected individually to test a component that has failed a test. After testing the individual component, option 1 must be selected again. The system is marked “commissioned” only after all tests pass.

In some tests the system recognizes the result of the test on its own. Other tests require the operator to type a N or Y to indicate the result of the test. N indicates no; Y indicates yes.

**NOTE:** Pressing the “Enter” key without entering “Y” or “N” is interpreted as no.

## Accelerometer Test



**WARNING:** The user must remain outside the robot workcell with all safety barriers closed while conducting these tests. Failure to observe this warning could cause serious injury.

The accelerometer is tested to ensure that it is operational. The MANUAL/AUTO and NETWORK key switches are checked by SAFE\_UTL. If a switch is in the improper position the following message is displayed:

\*\*\* Accelerometer Test \*\*\*

Switch the MANUAL/AUTO keyswitch to MANUAL and NETWORK keyswitch to OPEN position.

When the key switches are in the proper position the following message is displayed:

Program controlled move, expect E-Stop assert.

The default test locations are with Joint 1 at  $\pm 15$  degrees from midrange and all other joints at midrange.

Do you want to use the default test locations (Y/N)?



**WARNING:** Responding Y causes the robot to move joint 1 to the positions shown in Figure 8-1. If the robot is in its workcell, make sure the robot will not contact other tooling and/or fixtures, causing damage to the robot, tooling, and/or fixtures.

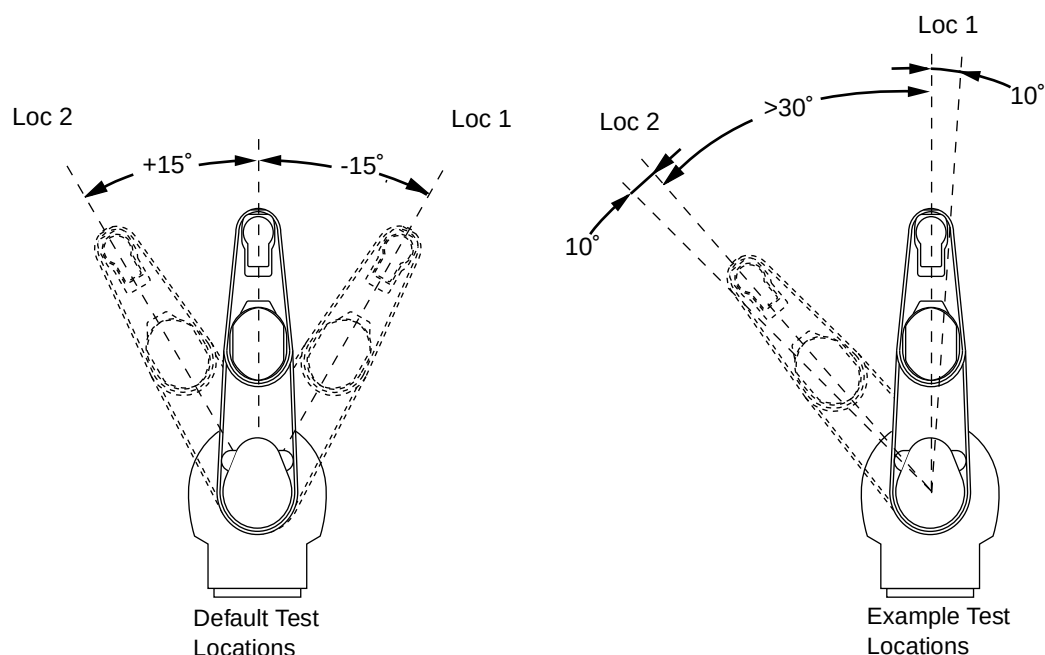


**Figure 8-1. Adept-XL Robot Test Locations**

Responding N allows new test locations to be defined. The test locations must be defined so that joint 1 is driven at least 30 degrees; see Figure 8-1. The robot will make a quick move during the test, causing the accelerometer to activate the E-Stop. The robot may overshoot slightly. To ensure the robot does not crash, it should be able to move 10 degrees beyond the defined locations in both directions. After the new test locations are defined, the following message is displayed:

Testing Joint 1

The test prompts will be displayed on the MCP as well as here on the monitor.

Release then press the Enable (Hold-to-run) button on the MCP. Press the High Power button when the button blinks.

Press the CMP/PWR button.

Hold the SPEED BAR then press and release the STEP button.

While continuing to hold the SPEED BAR, press and release the STEP button.

Accelerometer has tripped as expected.

The MCP controlled move is repeated. If the test passes, the following is displayed:

Accelerometer test passes.

Press ENTER to continue.

Pressing ENTER will either begin the next test to be performed, or display the main menu. If the test fails, the main menu is displayed.

## B+ Amp Voltage Restrict Test



**WARNING:** The user must remain outside the robot workcell with all safety barriers closed while conducting these tests. Failure to observe this warning could cause serious injury.

As this test is started High Power must be enabled as described in the previous test. The voltage restrict circuitry is tested to ensure that it is operational. The following messages are displayed, as the program progresses:

\*\*\* B+ Amp Voltage Restrict Test, Joint 3 \*\*\*

Program controlled move, expect E-Stop to assert.

The default test locations are with Joint 3 at +/- 50 mm from midrange and all other joints at midrange.

Do you want to use the default test locations (Y/N)?



**WARNING:** Responding Y may cause the robot to move joints 3 and 4 to the positions described below. Make sure the robot will not contact other tooling and/or fixtures, causing damage to the robot, tooling, and/or fixtures.

Respond N to define new test locations. The test locations must be defined so that joint 3 moves a minimum of  $\pm 50$  mm and joint 4 moves a minimum of  $\pm 90$  degrees. The robot will make a quick move during the test, causing the sensor to activate the E-Stop. The robot may overshoot slightly. To ensure the robot does not crash, it should be able to move slightly beyond the defined locations in both directions. After the new test locations are defined, joint 3 is tested first. The following messages are displayed as the program progresses:

Testing Joint 3

The test prompts will be displayed on the MCP as well as here on the monitor.

Release then press the Enable (Hold-to-run) button on the MCP.  
Press the High Power button when the button blinks.

Press the CMP/PWR button.

Hold the SPEED BAR then press and release the STEP button.

While continuing to hold the SPEED BAR, press and release the STEP button.

B+ Amp Tripped as expected.

Joint 4 is tested in the same manner as joint 3.

Press the CLR ERR button on the pendant; the following is then displayed:

B+ Amp Voltage Restrict test passes.

Press ENTER to continue.

Press ENTER to continue with the next test or return to the main menu.

## CIP Switch and Button Test

The CIP High Power button and lamp are tested to ensure that they are operational.

You are asked to test the MANUAL/AUTO and NETWORK keyswitches by changing their position. The following messages are displayed:

\*\*\* CIP Test \*\*\*

Keyswitch test:

Switch the MANUAL/AUTO keyswitch to AUTO and press ENTER.

As the keyswitch position is changed, the program verifies the state. If the test fails, the main menu is displayed. If the test passes, the High Power state test is performed and the following messages are displayed:

HIGH POWER state test:

Press and hold the HIGH POWER button on the CIP.

Release the HIGH POWER button.

As the High Power button is pressed, the program verifies its state. If the test fails, the main menu is displayed. If the test passes, the High Power enable test is performed and the following messages are displayed:

HIGH POWER Enable test:

Press ENTER, then press and release the HIGH POWER button while the button is flashing.

After pressing ENTER, the High Power push button must be pressed. If the test fails, the main menu is displayed. If the test passes, the E-Stop Button test is performed and the following messages are displayed:

EMERGENCY STOP Button test

Press the EMERGENCY STOP on the CIP.

Release the EMERGENCY STOP.

Press and then release the E-Stop button on the CIP. If the test fails, the main menu is displayed. If the test passes, the following messages are displayed:

CIP test passes.

Press ENTER to continue.

Press ENTER to continue with the next test or return to the main menu.

## MCP E-STOP Functions

The Enabling switch on the MCP is tested to ensure that it is operational. The following messages are displayed:

\*\*\* MCP Enable (Hold-to-run) Switch Test 1 \*\*\*

Release the Enable (Hold-to-run) switch on the MCP.

Is the red ES LED on the AWC Board on (Y/N)?

When the Enabling switch opens, the red ES LED on the AWC board should turn on. If the response is N, the test fails and an error message is displayed. If the response is Y, the following message is displayed:

Attempting to enable HIGH POWER with the MCP Enable switch released.

The test attempts to enable High Power and expects an E-Stop error. If High Power can be switched on, the test fails and an error message is displayed. If High Power cannot be switched on, the test passes.

\*\*\* MCP Enable (Hold-to-run) Switch Test 2 \*\*\*

Press and hold the MCP Enable switch.

Is the red ES LED on the AWC Board off (Y/N)?

When the Enabling switch closes, the ES LED on the AWC board should turn off. If you respond N, the test fails and an error message is displayed. If you respond Y, the system attempts to enable High Power. If High Power cannot be switched on, the test fails and an error message is displayed. If High Power is switched on, the High Power button is tested.

Press ENTER, then press and release the HIGH POWER button on the CIP.

Release the MCP Enable (Hold-to-run) switch and press ENTER to continue.

Press ENTER to begin the test and the system will attempt to turn on High Power. If High Power cannot be switched on, the test fails and an error message is displayed. If High Power is switched on, the MCP Enabling test passes.

Press ENTER to continue with the test.

Keep the MCP Enable switch pressed.

\*\*\* MCP E\_STOP Button Test 1 \*\*\*

Press the MCP E-STOP button.

Is the red E-STOP LED on the AWC module on (Y/N)?

Attempting to enable HIGH POWER with the E-STOP button pressed.

The external E-Stop error is expected. If High Power can be switched on, the test fails and an error message is displayed. If High Power cannot be switched on the test passes.

\*\*\* MCP E\_STOP Button Test 2 \*\*\*

Release the MCP E-STOP button.

Is the red ES LED on the AWC module off (Y/N)?

After releasing the E-Stop, the system will attempt to enable High Power. If successful, the following messages are displayed:

Press ENTER, then press and release the HIGH POWER button on the CIP.

Press the MCP E-STOP button and press ENTER to continue.

When the E-STOP button is released, the test is complete.

Release the MCP E-STOP button.

MCP E-STOP test passes.

Press ENTER to continue.

If all MCP tests pass, the next test is performed or the main menu is displayed.

## Brake Holding Force Test

The holding force of the brakes is tested to ensure that the robot cannot move when the brakes are engaged. The following message is displayed:

\*\*\* Brake Holding Force Test \*\*\*

The default test point is with all joints at midrange.

Do you want to use the default test point (Y/N)?

If you respond Y, the system prompts the user to move the robot to the desired location. If you respond N, the system uses the default location. The following message is displayed:

Press ENTER to enable power and move the robot to the test location.

High Power is switched on and joint 1 attempts to move with the brakes engaged, which should cause a failure. The following messages are displayed during the test:

Testing with brakes engaged.

Testing Joint 1

Press the HIGH POWER button when it blinks.

\*Motor stalled\* Mtr 1

After the system faults, joint 2 is tested. The High Power button must be pressed to switch on High Power. After testing of joint 2 is complete, joints 3 and 4 are also tested.

The system then tests Joints 1 to 4 with the brakes released.

If the Brake Holding Force test passes, the main menu is displayed. Exit SAFE\_UTL by selecting option 0 from the main menu. The following message is displayed:

```
The current robot has passed all MMSP tests.
```

```
The robot will be marked as "commissioned" in controller NVRAM.
```

```
Press ENTER to continue.
```

High Power can now be enabled with the MANUAL/AUTO key switch in the Manual position.

## Additional MMSP Diagnostic Tests

The MMSP menu includes three diagnostic tests, choices 7, 8, and 9, which allow you to perform tests independent of the MMSP Commissioning function. You can test the accelerometer, the B+ amp voltage restrict, and the CIP. Follow the instructions on the screen as you step through the tests.

## 8.7 Tests Performed Periodically

---

The Category 3 robot components must be tested every six months. These tests are performed using the SAFE\_UTL utility as described earlier.

There is one test in addition to the tests performed at the time of commissioning, the dual brake solenoid valve test.

When SAFE\_UTL is started, after the system has been successfully commissioned, the utility program displays the following menu and prompts the user to select an option.

```
*** Adept MMSP Test Programs (Version 13.0) ***
Copyright (c) 1998 by Adept Technology, Inc.
```

```
Robot 1: xxx-xxxx
```

```
0 => EXIT
1 => All Tests
2 => Accelerometer
3 => B+ Amp Voltage Restrict
4 => CIP Switches and Buttons
5 => MCP E-STOP Functions
6 => Brake Holding Force
7 => Dual Brake Valve
```

```
Enter Selection:
```



**WARNING:** In order to perform tests on the dual brake valve some access covers must be removed. The PA-4 power chassis should be switched off. These tests should be performed only by trained personnel.

## Required Tools

The following tools are required to perform the tests:

- M6 Allen wrench
- Flat-bladed common screwdriver

## Testing the Dual Brake Valves (With MMSP)



**WARNING:** The robot will move all joints to their midrange position. If the robot is in its workcell, make sure the robot will not contact other tooling and/or fixtures, causing damage to the robot, tooling, and/or fixtures.

Select the brake valve test option:

```
7 => Dual Brake Valve
```

The program displays the following prompt:

```
Do you want to use the default test point (Y/N)?  Y
```

Respond Y to enable High Power and move the robot to the test location (all joints in their midrange position). Press the High Power push button when prompted.

The robot moves to the test location and performs the first brake test. If the test passes, press ENTER to disable High Power and prepare for the next brake test. To complete the test you must remove the electrical bulkhead and then test each brake solenoid with its electrical connection removed.

Unscrew the eight M6 screws and remove the electrical bulkhead from the robot base (see Figure 8-2 on page 195). Do not disconnect any cables or air lines. When the bulkhead is removed and carefully set back, move out of the workcell and press ENTER to continue.

Unplug terminal lug #206 from brake valve #1 and move outside the robot workcell.

Press ENTER to enable High Power and test brake valve #1. Press the High Power push button when prompted.

If brake valve #1 is functioning properly, the system will disable High Power and you can plug terminal lug #206 back onto brake valve #1.

Move outside the workcell and press ENTER to test the next solenoid.

Unplug terminal lug #205 from brake valve #2 and move outside the robot workcell.

Press ENTER to enable High Power and test brake valve #2. Press the High Power push button when prompted.

If brake valve #2 is functioning properly, the system will disable High Power and you can plug terminal lug #205 back onto brake valve #2.

Move outside the workcell and press ENTER to complete the test. Press the High Power push button when prompted.

If the tests pass you are prompted to reassemble the electrical bulkhead. When the reassembly is complete, press ENTER to continue.

If all brake valve tests pass, the program returns to the main menu.

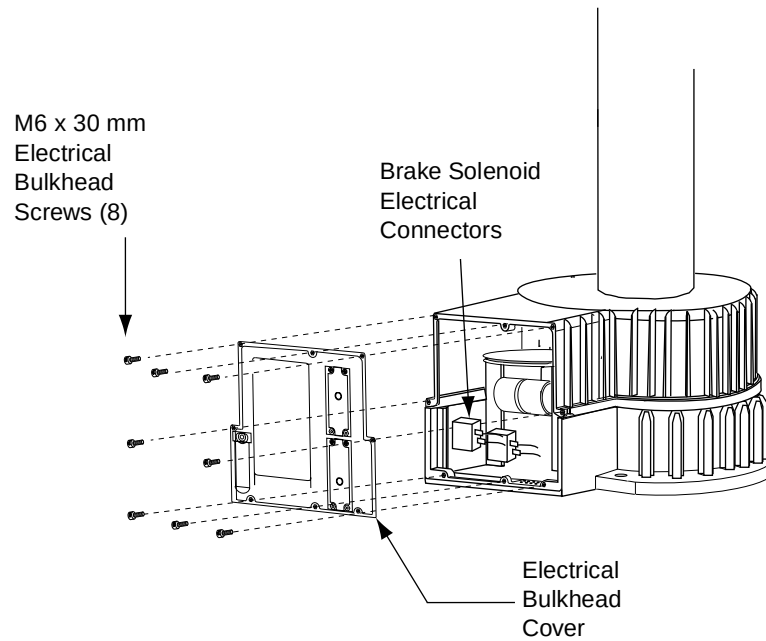


**Figure 8-2. Brake Solenoid Valve Electrical Connectors**



# Using the Manual Control Pendant (MCP) 9

---

The final step in verifying that the system is installed and working correctly is to move the robot through its range of motion using the MCP. The following sections tell you how to move all of the joints of the robot.

## 9.1 Robot Operating Modes

---

To safely move the robot you must understand the robot's two different operating modes, Manual and Automatic. The CIP has a two-position key switch that controls the robot's operating mode. For safety reasons, High Power is automatically disabled when the operating mode is changed.

### Manual Operating Mode

In the Manual (<250 mm/s) position, robot motion can be initiated only from the MCP. In Manual mode, the operator cannot initiate a motion with the system keyboard, and executing programs that require robot motion will halt, when a motion instruction is processed. This protects the operator in the workcell from unexpected motions of the robot.

In Manual mode the maximum speed of the tool center point and the joints of the robot is reduced to less than 250 mm per second (10 inches per second). Also, the motors run at reduced torque. This speed and torque reduction is implemented in the software. However, in Category 3 robots, this software limitation of speed and torque must be supported by redundant, self-checking hardware. The optional MMSP provides this additional hardware. If the robot tries to move with a higher speed, sensors in the robot and the power amplifiers will detect this fault and turn off High Power to the power chassis. The MMSP option uses a redundant (two-channel) design with automatic self-test.



**WARNING:** If an Adept-XL series robot is not equipped with the optional MMSP, the robot safety barriers must prevent any personnel from entering the workcell while amplifier power is turned on, even when the robot is in Manual mode. See "Category 3 E-Stop" on page 166 for requirements for robots not equipped with the MMSP option.

See section 1.13 on page 40 for a description of safety equipment for an operator who is working in the robot workcell.

In Manual mode, the contacts of the Customer Safety Barrier (Mute) are muted and the safety function of these contacts is disabled. This permits a skilled operator to enter the workcell while High Power is enabled. (This capability can be used *only* with the MMSP option.)

## Automatic Operating Mode

The Automatic mode (100%) position permits computer control of the robot. A program that is currently running the robot or motion device may cause it to move at times or along paths you may not anticipate. When the white High Power light on the CIP is illuminated, do not enter the workcell because the robot or motion device might move unexpectedly.



**WARNING:** Impact Hazard!

In Automatic mode no personnel are allowed in the workcell. The robot can move at high speeds and exert considerable force.

**NOTE:** The MCP can be used while the CIP is in either Automatic (AUTO) or Manual Mode. For example, it is possible to initiate calibration of the robot or to enable High Power from the MCP when the CIP is in Automatic (AUTO) mode.

## 9.2 Manual Control Pendant Basics

Adept motion systems are designed to allow control of the robot or motion device from the Manual Control Pendant (MCP). Figure 9-1 shows how to hold the MCP.

The pendant has a palm-activated enabling switch that is connected to the remote emergency stop circuitry of the controller. Whenever this switch is released, High Power is removed from the motion device. When the MCP is not being used, the operator must place it in the special cradle provided or remove it from the controller and install the pendant jumper plug. The cradle retaining clip will keep the enabling switch depressed when the pendant is not in use. Figure 9-2 shows how to place the pendant in its cradle.

To operate the MCP, put your left hand through the opening on the left-hand side of the pendant and use your left thumb to operate the pendant speed bars. Use your right hand for all the other function buttons. The various button groupings of the pendant are reviewed in this section.

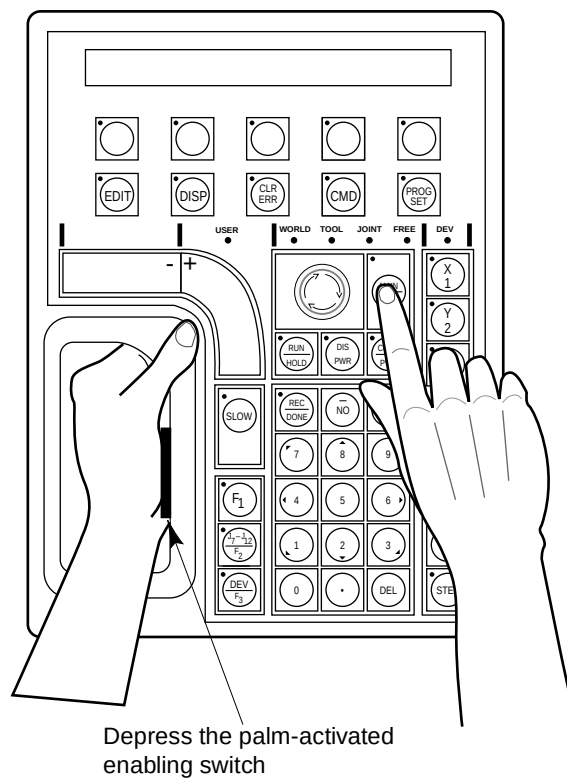


**Figure 9-1. Holding the MCP**

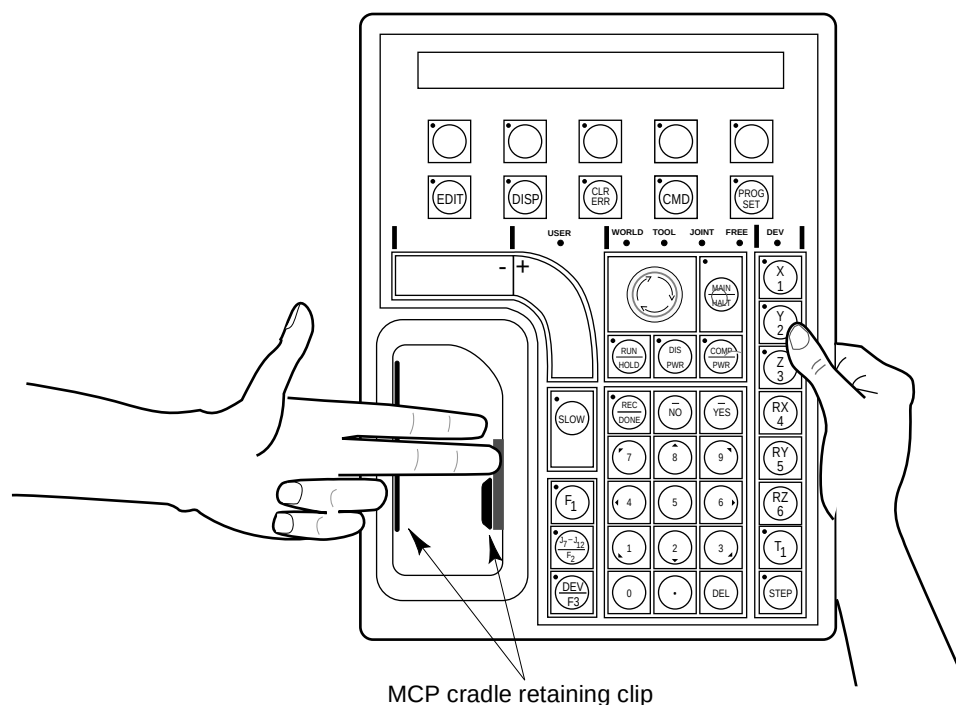


**Figure 9-2. Cradling the MCP**



**WARNING:** The cradle for the pendant **MUST** be mounted outside of the robot or motion device work envelope.

### Connecting the MCP

The MCP is connected to the 16-pin connector marked MCP on the CIP (see “Connecting the MCP to the CIP” on page 80). The pendant E-Stop button and the palm-activated enabling switch are wired into the emergency stop circuitry. Therefore, either the pendant or the optional pendant bypass plug must be attached to this connector. If neither one is connected, you cannot enable High Power. If the pendant or bypass plug is removed, High Power is turned off.

**NOTE:** The CIP design allows for an external MCP connection. If this connection is installed and used, the MCP bypass plug must be installed on the CIP MCP connector.



**CAUTION:** Do not modify or extend the MCP cable. Doing this will void the warranty on the MCP and the CIP.



**CAUTION:** Use only the MCP III, P/N 10332-11000 (Assy # 90332-48050, with a CIP). Other MCPs will not work with the CIP because they do not incorporate the dual E-Stop channels. Damage may result if an MCP III is plugged into older Adept controller systems that contain a VME Front Panel (VFP). Damage may also result if older MCPs (part numbers other than 10332-11000) are plugged into a CIP.



**WARNING:** The Auto/Manual keyswitch on the CIP *must* be set to Manual if the MCP is to be used inside the robot workcell. This enables important safety features to protect the operator by limiting the speed of the robot.

## MCP Layout

The major areas of the MCP are shown in Figure 9-3.

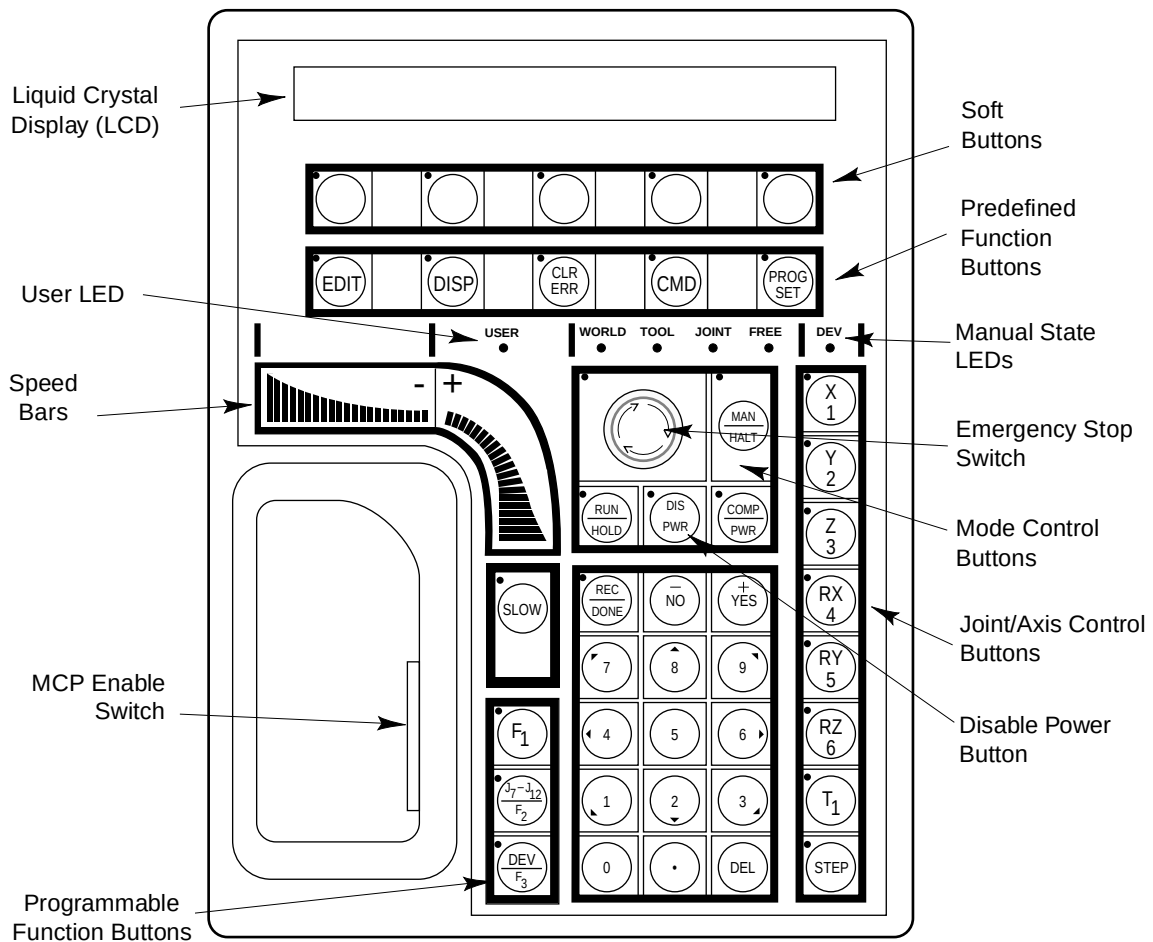


Figure 9-3. MCP Layout

### Soft Buttons

The soft buttons have different functions depending on the application program being run, or the selection made from the predefined function buttons. Whenever a soft button is active, its function is shown on the bottom line of the pendant display. Because these buttons do not have fixed labels (the labels are defined by the program using the buttons), they are referred to as soft buttons. (Programming the MCP is covered in the *V<sup>+</sup> Language User's Guide*.) Figure 9-3 shows the soft buttons.

## Function Buttons

The predefined function buttons have specific, system-wide functions assigned to them. These functions are covered in “MCP Predefined Functions” on page 203. The programmable function buttons are used in custom application programs, and their functions will vary depending upon the program being run. See the documentation for your application programs for details on these buttons. Figure 9-3 shows the function buttons.

## Data Entry Buttons

The data entry buttons shown in Figure 9-4 are used to input data, normally in response to prompts that appear on the pendant display. The data entry buttons include, +/YES, –/NO, DEL, the numeric buttons (0-9), the decimal point, and the REC/DONE button. These buttons are similar to the numeric keypad on a standard keyboard.

**REC/DONE Button** Behaves like the Return or Enter key on a standard keyboard. When data entry is complete, pressing REC/DONE sends the entry to the controller. In many cases, application programs have users press the REC/DONE button to signal that they have completed a task.

**DEL Button** Behaves like the backspace key on a standard keyboard. When data is being entered, it will appear on the pendant display. DEL will delete any characters that appear on the pendant display but have not been entered using the REC/DONE button. Application programs may also assign special functions to the DEL button.

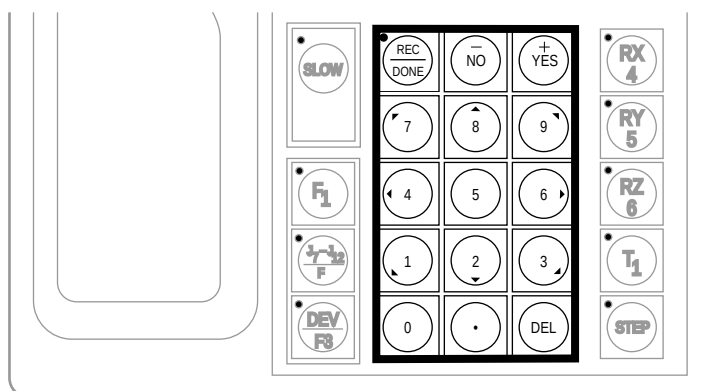


Figure 9-4. Data Entry Keys

## Mode Control and Joint/Axis Control Buttons

The mode control and joint/axis control buttons are used to control the robot from the pendant. The use of these buttons is covered in “Moving a Robot or Motion Device With the MCP” on page 210.

## Speed Bars and Slow Button

The speed bars and slow button are used primarily to move the robot when it is in Manual mode. These options are described in “Moving a Robot or Motion Device With the MCP” on page 210.

In some cases, application programs will make special use of the speed bars. See the documentation for any application program for details on how it uses these buttons.

## Emergency Stop From the MCP

To immediately halt program execution and turn off High Power, press the E-Stop button on the MCP. This switch has the same effect as pressing the E-Stop button on the controller.

To reenale High Power after pressing the MCP E-Stop button, turn the E-Stop button to the right (clockwise). The switch is spring loaded and will return to its normal position. Depress the enabling switch. High Power can now be reenaled by pressing the COMP/PWR button (mode control group), or by entering the ENABLE POWER command from the keyboard and then pressing the white High Power push button/lamp on the CIP.

## Background Mode

The pendant is in background mode when the USER LED is not lit and none of the predefined functions are being used. The USER LED is lit whenever an application program is making use of the MCP. The MCP will not return to background mode until the program completes execution or is aborted. The LEDs above the predefined function buttons indicate whether the functions are being used. If one of the LEDs is lit, the MCP can be returned to background mode by pressing the REC/DONE key (more than one press may be necessary). The predefined functions are described below in section 9.3.

When the MCP is in background mode, the viewing angle of the LCD can be changed. There are three different angles. Press the "2", "5", or "8" button to select a different viewing angle.

## 9.3 MCP Predefined Functions

### Introduction

This section describes the manual control pendant functions related to:

- Loading and starting programs
- Editing global variables
- Displaying system status

### Predefined Function Buttons

The MCP has five predefined function buttons. They are listed and explained below.

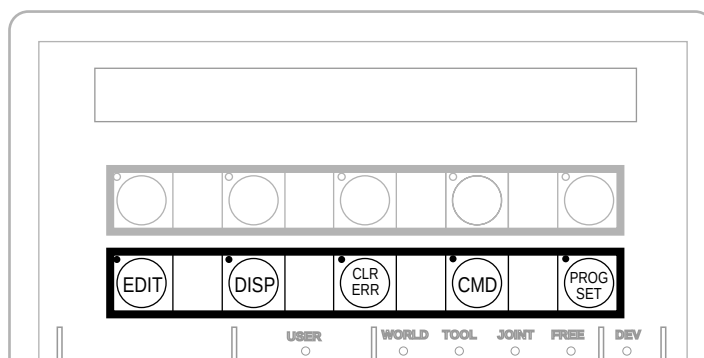


Figure 9-5. MCP Predefined Function Buttons

### The Edit Function

The Edit function button allows editing of location variables and real variables that are used by V<sup>+</sup> programs.

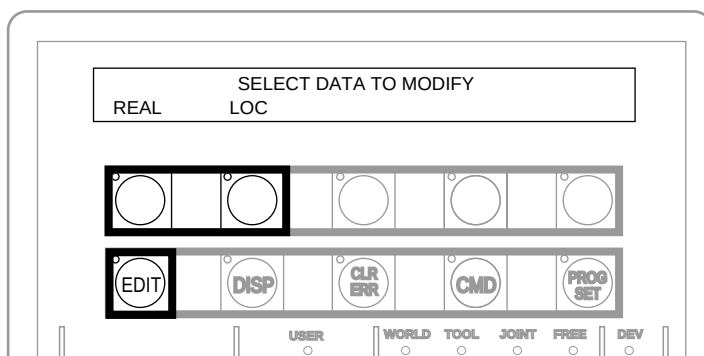


Figure 9-6. EDIT Function Button

**Real** Press the REAL soft button and the LCD displays:

```

SELECT REAL VARIABLE TO EDIT
var1    var2    var3    var4    <MORE>

```

var1, var2, etc., are global variable names. Press the soft button under the variable name to edit that variable. The <MORE> soft button is shown only when there are more than five global real variables in system memory. When a variable has been selected, the LCD will display:<sup>1</sup>

```

var.name = xxx
CHANGE    TRUE    FALSE

```

<sup>1</sup> If the variable being edited is from an array, an additional soft button is displayed that allows you to specify the index of the variable to edit.

Press the TRUE soft button to set the variable to the Boolean value of true (-1). Press FALSE to set the variable to false (0). To change the value of the variable press the CHANGE soft button. The LCD displays:

```
var.name = _
CHANGE    TRUE    FALSE
```

The typing cursor replaces the variable value. Use the data entry buttons to input a new value, and complete the entry by pressing REC/DONE.

**Loc** Press the LOC soft button and the LCD displays:

```
SELECT LOCATION VARIABLE TO EDIT
loc1    loc2    loc3    loc4    <MORE>
```

Press the soft button under the variable name to edit that variable. The <MORE> soft button is shown only when there are more than five global location variables in system memory. When a variable has been selected, the LCD will show:<sup>1</sup>

```
loc.name: X = 500
CHANGE    NEXT    HERE
```

If a precision point is selected, the LCD will show:

```
#loc.name: Jt1 = -210
CHANGE    NEXT    HERE
```

Press the CHANGE soft button to change the displayed component of the location variable. The value will disappear and be replaced with the typing cursor. Use the data entry buttons to enter a new value, and complete the entry by pressing REC/DONE.

Press the NEXT soft button to show the next component of the location variable. The location's X, Y, Z, y, p, and r values will be shown in succession. X, Y, and Z values are given in millimeters; y, p, and r values are given in degrees. If a precision point is being edited, the joint values for all the joints in the robot will be shown in succession.

Press the HERE soft button to record the current robot location in the variable being edited.



**WARNING:** Be extremely careful when changing location values. When the robot moves to a modified location, it could damage equipment in the workcell.

<sup>1</sup> If the variable being edited is from an array, an additional soft button is displayed that allows you to specify the index of the variable to edit.

## The Display Function

The Display function button allows either the current joint values, the current world location, the system status, the digital I/O status, or the last error message to be displayed on the MCP.

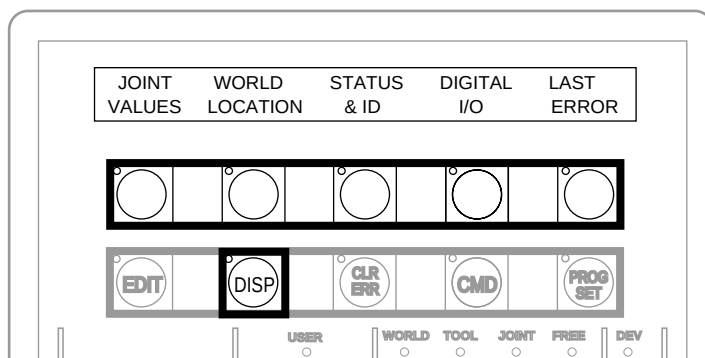


**Figure 9-7. DISPLAY Function Button**

**Joint Values** When this button is pressed, the display shows:

J1 = x.xx    J2 = x.xx    J3 = x.xx  
J4 = x.xx    J5 = x.xx    J6 = x.xx

These values represent the current joint positions of the robot or motion device. Values will be shown only for joints the robot or motion device actually has. Rotational joint values are expressed in degrees, and translational joint values are expressed in millimeters.

**World Location** When this button is pressed, the display shows:

X = xxx.xxmm    Y = xxx.xxmm    Z = xxx.xxmm  
y = xxx.xx°    p = xxx.xx°    r = xxx.xx°

The values represent the current location of the robot or motion device in world coordinates. See “Moving a Robot or Motion Device With the MCP” on page 210 for details on world coordinates.

**Status & ID** When this button is pressed, the display shows:

|        |          |        |       |
|--------|----------|--------|-------|
| Status | SOFTWARE | CNTRLR | ROBOT |
| ID     | ID       | ID     | 'S    |

The **Status** button displays:

|              |       |       |      |
|--------------|-------|-------|------|
| program.name | 50    | 1     | 0    |
| Program      | Speed | Cycle | Left |

Program shows the name of the currently executing or most recently executed program. Speed shows the current monitor speed. Cycle shows the total number of cycles specified when the program was executed. Left shows the number of cycles of the program remaining to execute.

The **Software**, **Controller**, and **Robot ID** buttons display the ID information for those items.

**Digital I/O** When this button is pressed, the display shows:

```

----- 0000 0011
+ 0032-0001 -      OUT      IN      SOFT

```

The top line shows the status of the range of digital I/O signals indicated on the second line (1-32 in the above example). A “-” indicates the channel is not installed, a “1” indicates the signal is on, and a “0” indicates the signal is off. The type of signal that is being displayed is indicated by the LED on the soft buttons labeled OUT, IN, and SOFT. The above example shows digital output signals in the range 1 to 32. Signals 1-2 are on, signals 3-8 are off, and no other signals in this range are installed.

To display a different range of signals, press the soft buttons under the “+” or “-” labels. The next or previous range of signals will be displayed. Press the OUT, IN, and SOFT soft buttons to display input, output, or soft signal ranges. See “Connecting User-Supplied Digital I/O Equipment” on page 173 for details on digital I/O signal ranges for the CIP. Also see “Extended Digital I/O Signals” on page 177 for details on digital I/O signal ranges for the optional DIO board.

**Last Error** Press LAST ERROR to display the error messages generated by V<sup>+</sup> during the current session. The most recent error will be displayed. The rightmost soft button will be labeled <MORE>. Pressing this button will cycle back through the error messages generated during the current session.

### The Clear Error Function

If the MCP is in the Manual position, or the system switch MCP.MESSAGES is enabled, error messages are sent to the MCP. When an error is sent to the MCP, the MCP will beep, display a blinking error message, and light the LED on the CLR ERR button, shown in Figure 9-8.

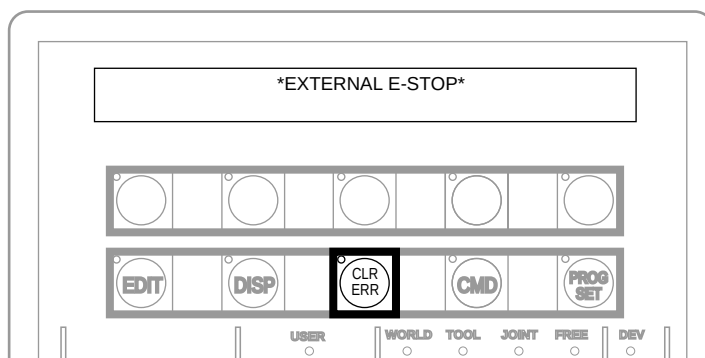


**Figure 9-8. CLEAR ERROR Function Button**

The CLR ERR button must be pressed for operation to continue. Pressing the CLR ERR button will clear the error message from the display and return the MCP to the state it was in before the error.

### The CMD Function

The CMD function button displays the options AUTO START, CALIBRATE, STORE ALL, CMD1, and CMD2, as shown in Figure 9-9.

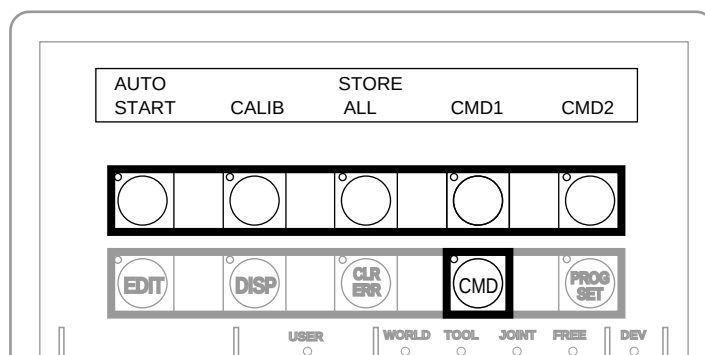


**Figure 9-9. Command (CMD) Function Button**

The AUTO START, CALIB, CMD1, and CMD2 functions require the MCP to be in Auto mode. If one of these function buttons is pressed while the MCP is in Manual mode, the MCP prompts you to place the keyswitch in the Auto position. The operation is halted and you must press the function button again. The programs started by these buttons may include a WAIT.START instruction, in which case the program will pause and the MCP will display START and CANCEL buttons over the two right soft buttons. Pressing START allows the program to continue. Pressing CANCEL halts program execution.

The programs started by these functions run in task 0. Therefore, High Power must be enabled and the robot must be calibrated.

**Auto Start** When AUTO START is pressed, the pendant display shows:

Enter last two digits of file name:

auto\_

Enter one or two digits and press REC/DONE. The system attempts to load the file AUTOxx.V2 from the default disk, and COMMAND the program "autoxx" (xx refers to the digits you entered). The program file AUTOxx.V2 must reside on the default disk, and it must contain a monitor command program named "autoxx". If the file does not exist, or does not contain a correctly named program, the operation will be aborted and the appropriate error message will be displayed on the LCD. For example, if you had entered "9", the system would attempt to load the file AUTO9.V2 and COMMAND the program "auto9".

**Calib** When CALIB is pressed, the robot calibration procedure begins (High Power must be enabled).

**Store All** When STORE ALL is pressed, the pendant displays:

Enter last two digits of file name:

STORE auto\_

Enter one or two digits, press REC/DONE, and all programs and variables in system memory will be stored to a file on the default disk with the name autoxx.v2. For example, if you had entered "11", the file AUTO11.V2 would be created, and all programs and global variables in system memory would be stored to that file.

**CMD1 and CMD2** When CMD1 is pressed, the system attempts to load the file CMD1.V2 from the default disk, and COMMAND the program CMD1. The program file CMD1.V2 must reside on the default disk, and it must contain a command program named "cmd1". If the file does not exist, or does not contain a correctly named program, the operation will be aborted and the appropriate error message will be displayed on the LCD. If CMD2 is pressed, the file CMD2.V2 will be loaded and "cmd2" will be COMMANDEd.

### Prog Set Function

Using the Prog Set button, you may select a new program to execute, set the starting step number, set how many cycles of the program to perform, set the monitor speed, and start a memory-resident application program. See Figure 9-10.

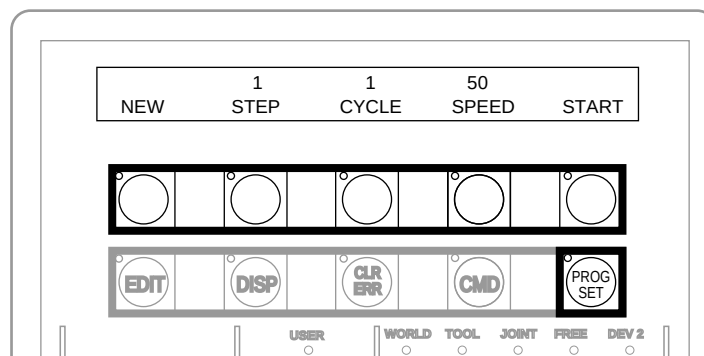


Figure 9-10. Program Set Function Button

**New** Press the NEW soft button and the LCD displays:

SELECT A NEW PROGRAM

prog1      prog2      prog3      prog4      <MORE>

To select a different program, press the soft button under the program name. To see additional programs (if there are more programs), press the <MORE> soft button.

**Step** Press STEP and the step number will blink, and the typing cursor will appear next to the step number. Use the data entry buttons to enter the program step to start execution. Complete the entry by pressing REC/DONE.

**Cycle** Press CYCLE and the cycle count will blink, and the typing cursor will appear next to the cycle count. Use the data entry keys to enter the number of program cycles to execute. Complete the entry by pressing REC/DONE.

**Speed** Press SPEED and the current monitor speed will blink, and the typing cursor will appear next to the monitor speed. Use the data entry keys to enter a new monitor speed. Complete the entry by pressing REC/DONE.

**Start** The Start button works only when High Power is enabled (this option cannot be used with DRY.RUN enabled). Press START and the program displayed above the NEW soft button will begin execution.

## 9.4 Moving a Robot or Motion Device With the MCP

---

### Introduction

The MCP is used with a robot or motion device primarily to teach robot locations for use in application programs. The MCP is also used with custom applications that employ teach routines that pause execution at specified points and allow an operator to teach or reteach the robot locations used by the program. The Adept AIM software system makes extensive use of the pendant for teaching robot locations.

When you move the robot using the MCP, motion will be in world state, tool state, joint state, or in free state.

When moving in world state, directions are sent from the MCP to move the robot in a Cartesian coordinate system centered at the base of the robot. When moving in tool state, directions are sent from the MCP to move the robot in a Cartesian coordinate system centered at the robot's end-of-arm tooling location.

In joint state, directions are sent from the MCP to move individual robot joints. In free state, selected joints of the robot are "freed" from servo control so they can be moved by hand.

## Mode Control Buttons

The mode control buttons, Figure 9-11, change the state being used to move the robot, switch control of the robot between the MCP and application programs, and enable High Power (when necessary).

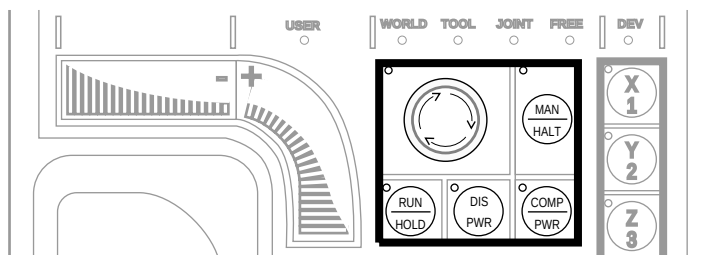


Figure 9-11. Mode Control Buttons

### Emergency Stop Button

The emergency stop button will stop program execution and turn off High Power. If your robot is equipped with brakes, they will be activated.

### COMP/PWR Button

If High Power is enabled, the COMP/PWR button selects computer mode. If the system is in AUTO mode and High Power is disabled, the COMP/PWR button enables High Power and selects computer mode. In computer mode, an executing program or the system terminal has control of the robot.<sup>1</sup> After you press the COMP/PWR button to enable High Power, the High Power lamp begins blinking and the LCD prompts you to press the High Power button. You must press this button within the allowed time (this time is programmable) or High Power will not be enabled.

If the system is in Manual mode and you press the COMP/PWR button to enable High Power, you need to take the following actions:

- release the MCP enable switch
- press and hold the MCP enable switch
- press the High Power button within the allowed time.

### MAN/HALT Button

When there is no program executing, or a program has paused for a pendant teach routine, pressing the MAN/HALT button selects manual mode. In manual mode, the MCP has control of the robot. If a program is executing, the MAN/HALT button will stop program execution (without shutting off High Power).

Manual mode cannot be entered if High Power is off (the E-Stop button LED is not illuminated). To enable High Power, press the COMP/PWR button. The MCP is in manual mode when:

1. The LED on the MAN/HALT button is illuminated, and

<sup>1</sup> If the robot has not been calibrated and High Power is turned on, the MCP E-Stop switch LED will be lit, and both the COMP/PWR and MAN/HALT LEDs will be off.

2. One of the manual state LEDs is also illuminated (the manual state LEDs indicate the type of manual motion that has been selected, either World, Tool, Joint, or Free).

The system will remain in Manual mode until High Power is turned off or the COMP/PWR button is pressed. When you have finished moving the robot manually, press the COMP/PWR button to return control to the controller. If a program attempts to execute with the MCP in manual mode, the error "Comp mode disabled" will be displayed.

When the MAN/HALT button is pressed the first time, the MCP will be in world state. Pressing the MAN/HALT button again selects the next state to the right (tool, joint, free), eventually wrapping back to the leftmost state (world). If manual mode is terminated and reentered (without turning off system power) the last active state is selected.

As an additional safeguard, when High Power is enabled and the CIP switch is turned to Manual, High Power is disabled and any Manual mode selection is canceled.

### **DIS PWR Button**

The Disable Power button will shut down High Power to the robot or motion device when pressed. Unlike the E-Stop Button, the Disable Power Button initiates a controlled stop, where the robot is decelerated under software control. After the robot has stopped, power is turned off.

### **RUN/HOLD**

When the RUN/HOLD button is initially pressed, it will stop the robot and pause the executing program (task 0). If you then press and hold down the button, the program proceeds until the button is released. When the button is released, the robot stops and the executing program pauses until the button is pressed again.

## **Joint/Axis Control Buttons**

The buttons on the far right side are the joint/axis control buttons. When the MCP is in manual mode, these buttons select which robot joint will move, or the coordinate axis along which the robot will move. The X/1, Y/2, Z/3, RX/4, RY/5, and RZ/6 buttons are covered starting on page 213. (The MCP must be in manual mode before a joint/axis control button can be selected.)

### **STEP Button**

When the CIP keyswitch is set to Manual, V<sup>+</sup> programs cannot initiate motions unless you press the STEP button and speed bar on the MCP. To continue the motion once it has started, you can release the STEP button but must continue to press the speed bar. Failure to operate the STEP button and the speed bar properly results in the following error message:

\*Speed pot or STEP not pressed\*

Once a motion has started in this mode, releasing the speed bar also terminates any belt tracking or motion defined by an ALTER program instruction.

Motions started in this mode have their maximum speeds limited to those allowed in Manual mode.

Programs designed to allow moving the robot in Manual mode should read the status of the STEP button and speed bars before starting the move. The program should prompt the user as required.

## Speed Bars

### In World, Tool, and Joint Mode

The speed bars are used to control the robot's speed and direction. The joint(s) that will move when the speed bars are pressed depends on the "state" selected with the MAN/HALT button. Press the speed bars with your left thumb. Pressing the speed bars near the outer ends will move the robot faster; pressing the speed bar near the center will move the robot slower. See "Robot States" below for details on positive and negative directions.

### In Comp Mode

See the description of the STEP Button on page 212.

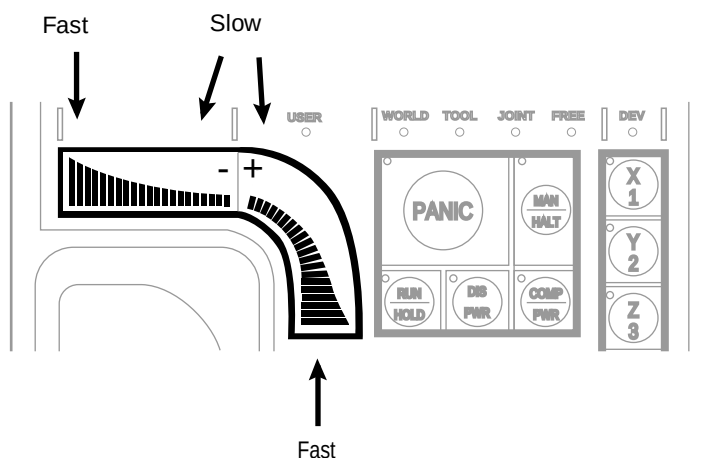


Figure 9-12. Speed Bars

## Slow Button

The slow button selects between the two different speed ranges of the speed bars. When the slow button LED is lit, the slower speed range is selected. This slower speed is 25% of the normal MCP speed.

## Robot States

### World State

When world state is selected, movement in the X, Y, or Z direction is parallel to an axis of the world coordinate system. Before the speed bars will move the robot, an axis of motion must be selected from the manual control buttons. The world coordinate system for a SCARA robot is shown in Figure 9-13. If X1 is selected, pressing the "+" speed bar will move the robot tool flange in the positive X direction. Pressing the "-" speed bar will move the flange in the negative X direction.

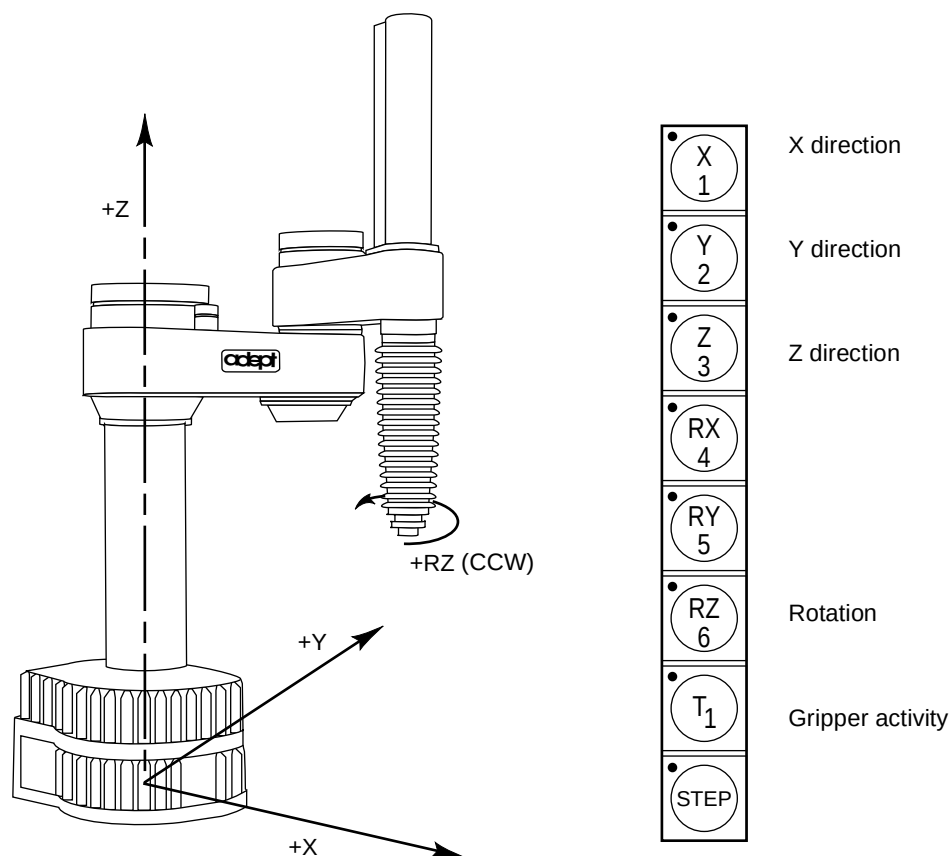


**Figure 9-13. WORLD State (Four-Axis SCARA)**

The  $T_1$  button cycles the gripper solenoids. Press anywhere on the “+” side of the speed bar to open the gripper, on the “-” side to close the gripper.

**NOTE:** This is the most common gripper setup. The gripper solenoids may be configured so they operate differently (or they may not be configured at all). Place your robot in a safe location and cycle the gripper to verify which side of the speed bar opens the gripper.<sup>1</sup>

### Tool State

When tool state is selected, movement in the X, Y, or Z direction is along an axis of the tool coordinate system. The tool coordinate system is centered at the robot tool flange with the Z axis pointing away from the flange. On most robots, the positive X axis is aligned with the center of the tool flange keyway. Before the speed bars will move the robot, an axis of motion must be selected from the manual control buttons. If X1 is selected, pressing the “+” speed bar will move the robot tool flange in the positive X direction. Pressing the “-” speed bar will move the flange in the negative X direction.

In a four-axis robot, positive rotation of the gripper (RZ) is clockwise as viewed from above. Figure 9-14 shows the tool coordinate system for a four-axis SCARA robot.

<sup>1</sup> The SPEC utility is used to configure gripper activity. See the *Instructions for Adept Utility Programs*.

Figure 9-15 shows the tool coordinate system on a six-axis robot.

**NOTE:** Figure 9-14 and Figure 9-15 are drawn with the assumption that the TOOL transformation is set to NULL (all values are 0). If a TOOL transformation is in effect, the tool coordinate system will be offset and rotated by the value of the TOOL transformation. Any motion in tool state will now be relative to the offset coordinate system, and not the center of the tool flange. See the *V<sup>+</sup> Language Reference Guide* for details on TOOL transformations.

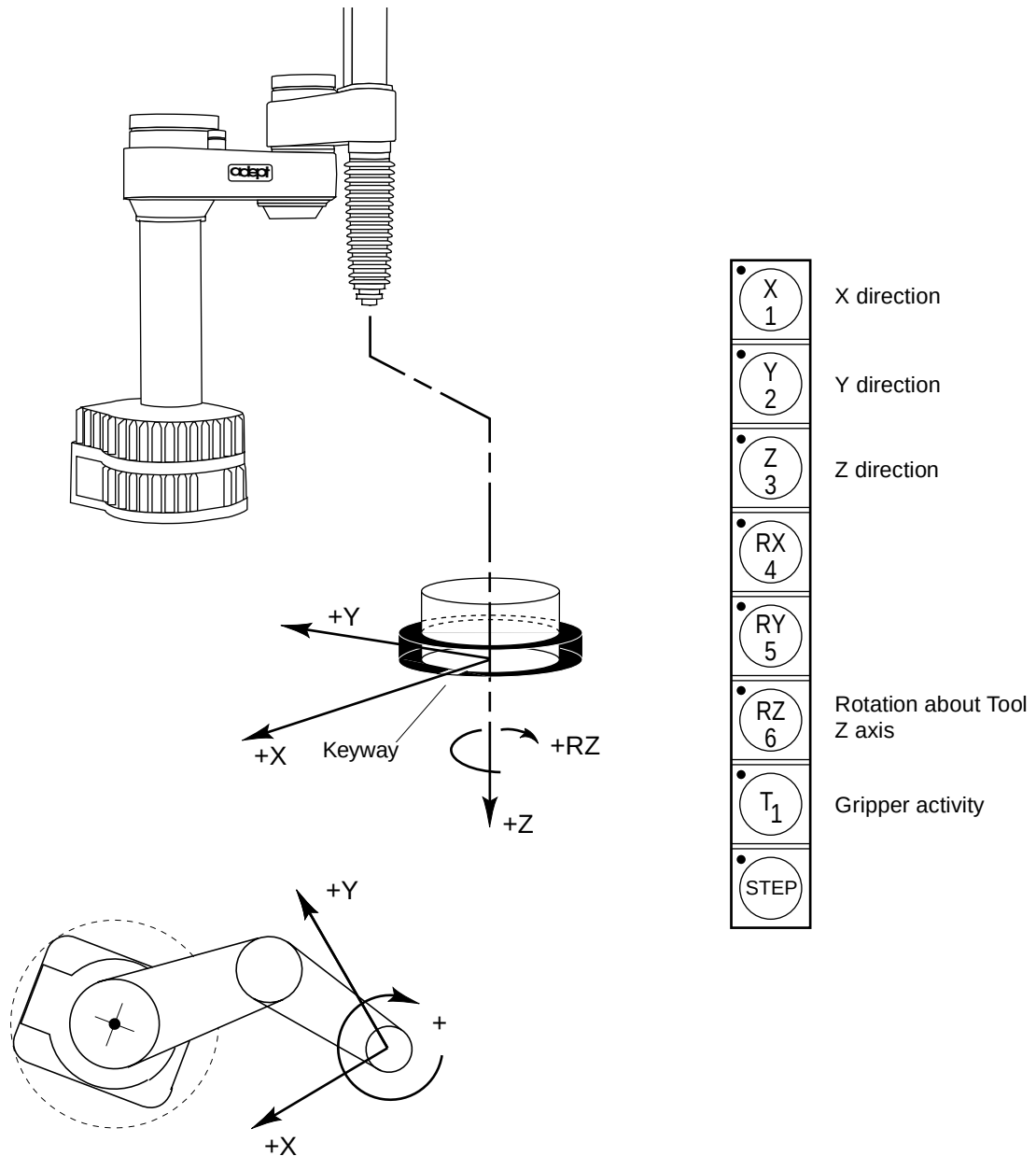


Figure 9-14. TOOL State (Four-Axis SCARA)

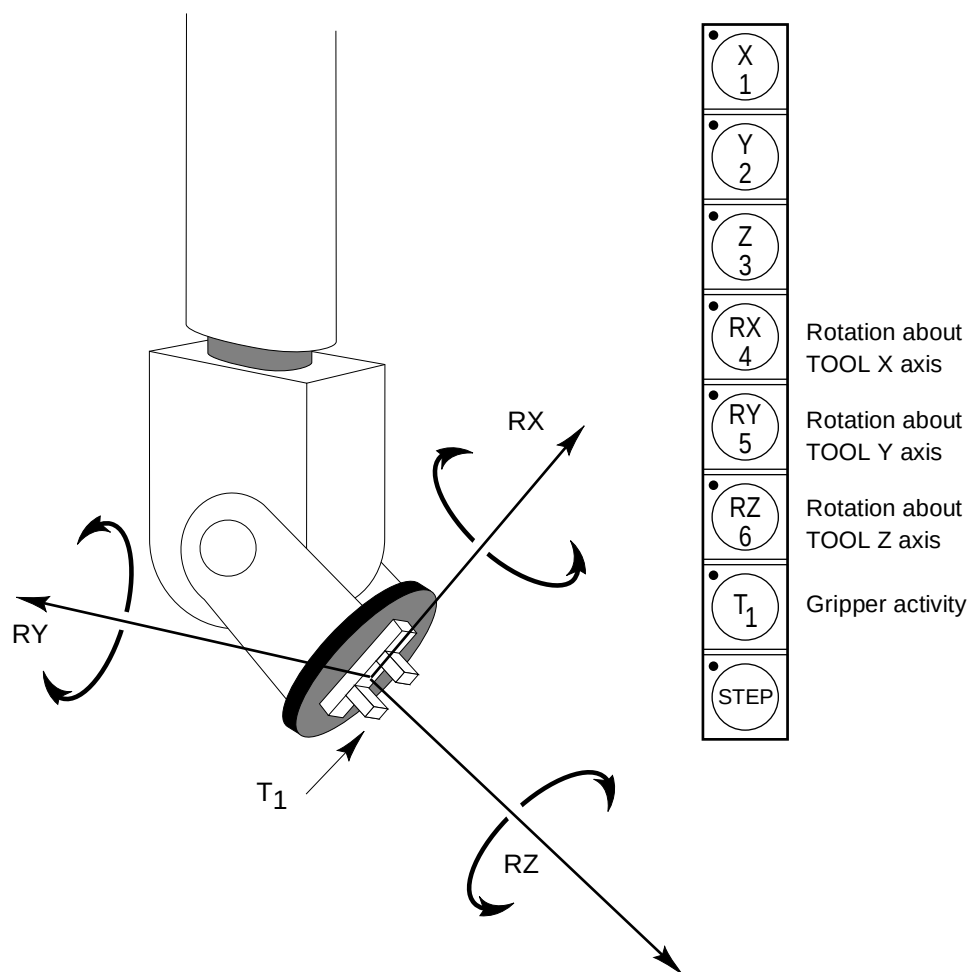


Figure 9-15. TOOL State (Six-Axis Robot)

### Joint State

When joint state is selected, movement is about the axis of the specified joint. Figure 9-16 shows an Adept SCARA robot with three rotational joints (joints 1, 2, and 4) and one translational joint (joint 3). Positive rotation of joints 1 and 2 is counterclockwise as viewed from above. Positive rotation of joint 4 is clockwise as viewed from above. Positive movement of joint 3 is downward. Before the speed bars will move a joint, the correct joint must be selected from the manual control buttons.

Different robots or motion devices will have the different joint numbers assigned to their joints. When you first move an unfamiliar robot using joint state, set the monitor speed to 10 or lower, put the robot in a safe area, and carefully move the robot using the different joint numbers to verify how the MCP moves the robot. See the documentation for the motion devices you are using for details on their joint assignments.

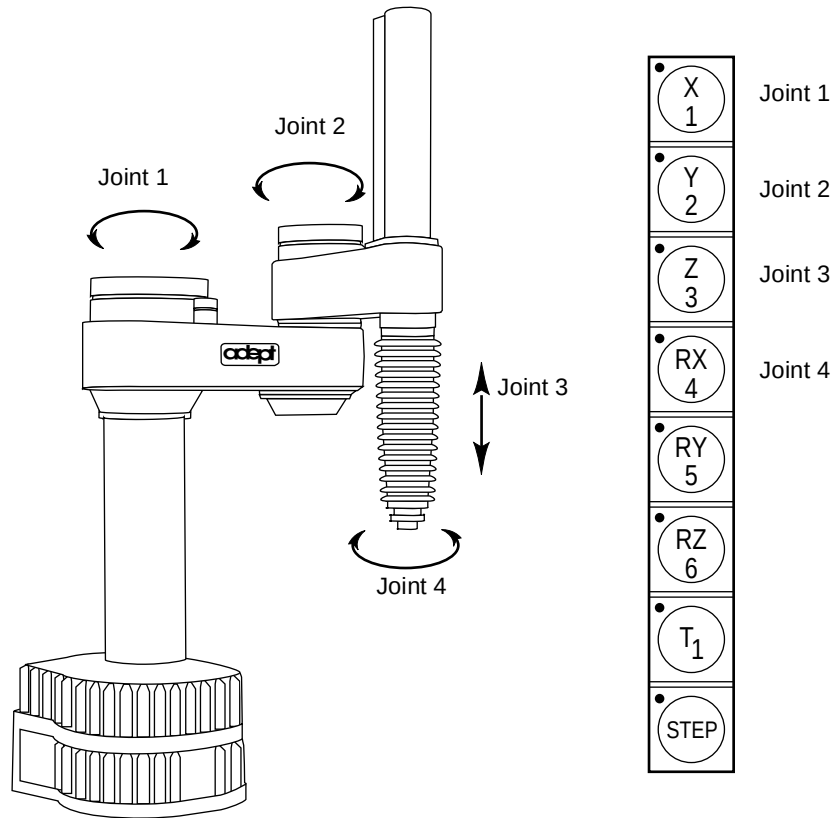


**Figure 9-16. JOINT State (Four-Axis SCARA)**

Figure 9-17 shows the joint assignments for a typical six-axis robot (as always, the first time you move a robot, carefully verify the joint assignments).

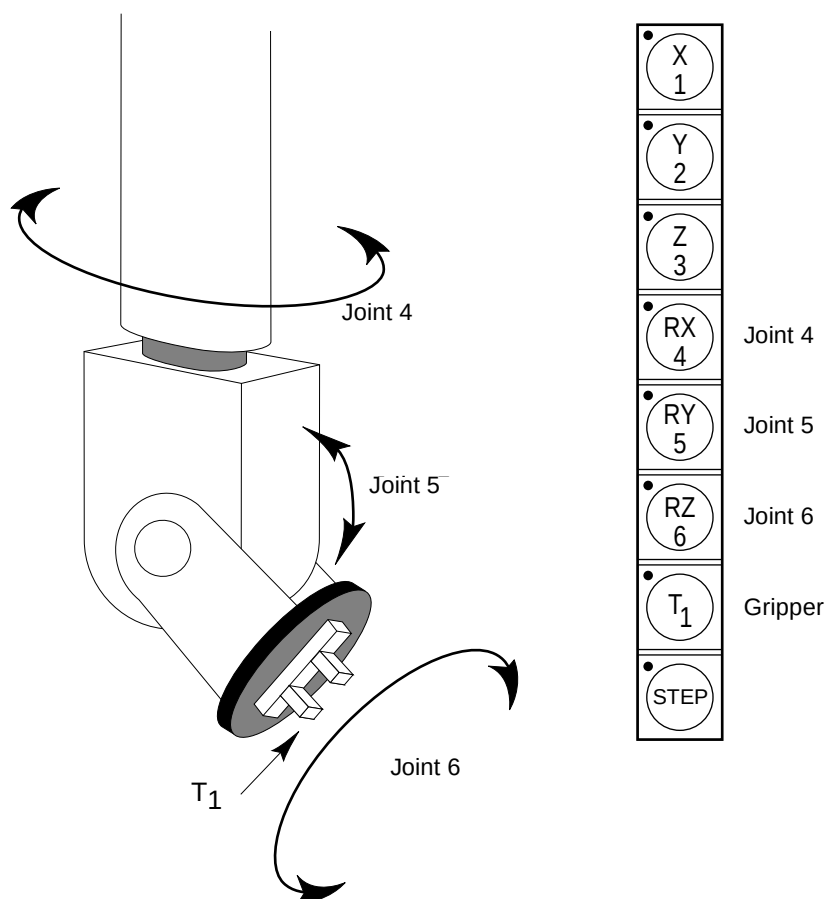


Figure 9-17. JOINT State (Six-Axis Robot)

### Free State

When free state is selected, individual joints are freed from servo control, and the robot brakes (if any) are released. Unlike the other states, you can make multiple selections from the manual control buttons to free as many joints as required. In some cases, such as joints 1 and 2 on an AdeptOne/AdeptThree robot, multiple joints are freed by selecting a single button. On some robots Free mode may have been disabled by the manufacturer on some or all joints.

As soon as the COMP/PWR button is pressed, or another selection is made from the manual control buttons, all joints are placed back under servo control and will not move freely.

Figure 9-18 shows the free state for a four-axis SCARA robot. The joint assignments in the free state are the same as the joint assignments in joint state.



**WARNING:** As soon as a joint is selected from the manual control buttons, the related joint is free to move (in some cases, multiple joints may be freed up). In many cases the weight on the joint will be sufficient to move the joint and cause damage or harm. For example, when joint 3

on a SCARA or Cartesian robot is freed, the joint is free to fall to the end of its travel. In articulated robots, multiple links of the robot may be free to fall when a single joint is freed up. Be extremely careful when selecting a joint in Free mode.

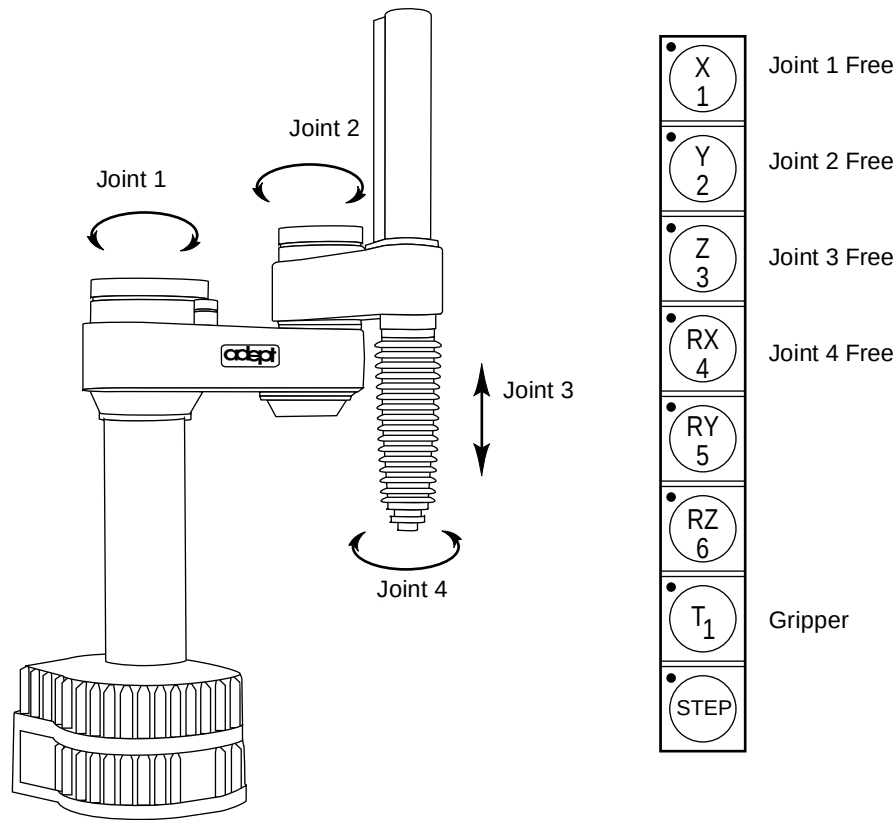


**Figure 9-18. FREE State (Four-Axis SCARA)**

## Controlling More Than One Robot

Like the monitor and each program task, the MCP also can have a robot attached. When moving a robot from the MCP or displaying joint values or world locations by pressing the DISP key, only the currently selected robot is affected. The robot currently selected by the MCP is shown by the state of the DEV LED (in the manual state LED group, see Figure 9-3 on page 201). The table below describes the conditions:

| DEV LED state | Robot selected by pendant |
|---------------|---------------------------|
| OFF           | 1                         |
| ON            | 2                         |
| FLASHING      | 3 (and above)             |

The selected robot cycles from one robot to the next each time the DEV/F3 key is pressed. Be careful when recording positions with the MCP; the position recorded by HERE or TEACH commands depends on the robot that is currently selected by the monitor or program and not on the robot selected by the MCP. The following commands will allow you to teach the position of robot 2 regardless of which robot is selected by the MCP.

```
.SELECT ROBOT = 2          ;Choose robot to be accessed by Monitor
.TEACH p[1]                ;Record location(s) of robot 2
```

### Robots With Fewer Than Six Joints

The MCP has six axis/joint selection buttons. In Cartesian modes (WORLD, TOOL), these correspond to all six possible Cartesian values: X, Y, Z, RX, RY, RZ. Not all mechanisms can move in all of these coordinates. For example, a 4-axis SCARA robot can move in only X, Y, Z, and RZ. Buttons that have no effect on your robot are ignored and in some cases cannot be selected.

### Robots With More Than Six Joints

In JOINT mode, each of the six buttons is used to control a specific joint of the robot. If the robot has more than six joints, the F2/J7-J12 key can be used to access the 7th to 12th joints. Only the robot currently selected by the MCP is affected. The currently selected joint is shown by the state of the LED on the joint/axis key as described below. If you press the key for joint 1, and the LED is steady, you are controlling joint 1. If you press F2/J7-J12, then press the key for joint 1, the LED will flash, indicating that you are controlling joint 7.

**Table 9-1. Robots With More Than 6 Axes**

| Joint/Axis LED state | Joint range |
|----------------------|-------------|
| OFF                  | None        |
| STEADY               | 1 to 6      |
| FLASHING             | 7 to 12     |

The MCP cycles from one range to the other each time the F2/J7-J12 key is pressed.

# Maintenance 10

The Adept-XL robot requires very little maintenance due to its direct-drive design. Joint 1 and 2 bearings need no maintenance at all. This chapter describes the preventive maintenance procedures that are required to keep the robot system operating properly.

**NOTE:** The Adept-XL IP54 robot requires additional maintenance relating to rotary seal assemblies. Please refer to section 10.7 on page 234 for this maintenance information.

See Table 10-1 for a summary of the preventive maintenance procedures and guidelines on frequency.

**Table 10-1. Recommended Preventive Maintenance Schedule**

| Item                                                           | Recommended Schedule (hours)               |
|----------------------------------------------------------------|--------------------------------------------|
| Lubricate the upper and lower quill shaft                      | Every 3 months or approximately 1000 hours |
| Lubricate joint 1 encoder gear                                 | Every 3 months or approximately 1000 hours |
| Check all screws in robot cover plates and robot mounting base | Monthly                                    |
| Check all cable connections                                    | Monthly                                    |
| Drain robot compressed air filter moisture trap                | Monthly                                    |
| Check air filters on controller and power chassis              | Monthly                                    |
| Check air filter at robot base                                 | Monthly                                    |
| Run Safety Utility (MMSP Option only)                          | Every six months                           |

**NOTE:** The frequency of these procedures will depend on the particular system, its operating environment, and amount of use. Use the times in Table 10-1 as guidelines and modify the schedule as needed.



**WARNING:** The procedures and replacement of parts mentioned in this section should be performed only by skilled or instructed persons, as defined in section 1.12 on page 39. The access covers on the robot are not interlocked; disconnect power if covers must be removed.

## 10.1 Testing the MMSP Hardware

Run the safety utility program every six months to test the components of the Category 3 safety system. See “Using the SAFE\_UTL Program (MMSP Only)” on page 184 for details.

## 10.2 Robot Lubrication

The quill shaft and joint-1 encoder gear require periodic lubrication. The frequency of lubrication will depend on the operating environment and amount of use. Initially, check the lubrication areas of the Adept-XL robot once a month. Record the results and produce a schedule appropriate to the particular system, its environment, and use.

**NOTE:** For the Adept-XL IP54 Robot, plan on lubricating every three months.

To check for adequate lubrication at the Joint-3 **upper** quill, remove the upper quill cover and run a finger along the quill. A thin film of grease should be present. If the shaft is dry, it needs lubrication.

### Recommended Grease for the Adept-XL Robot

#### Joint-1 Encoder Gear

LUBRIPLATE MO-LITH No. 2,  
a molybdenum disulfide based grease  
(USDA H2 Molybdenum grease)

Adept part number: 85151-00003

#### Joint-3 (Upper and Lower) Quill Shaft

Mystik® SynGuard™ SX-6™ 5448 (or equivalent) NLGI 2,  
high temperature lithium complex, EP grease  
(CATO Oil and Grease Co., Oklahoma City, OK)

Adept part number: 85114-31680



**CAUTION:** Using improper lubrication products on the Adept-XL robot may cause damage to the robot.

#### Manufacturer's Safety Data Sheets (MSDS)

The manufacturer's safety data sheets for the greases used in the Adept-XL robots are available from the Adept FAXback system at the numbers listed in “How Can I Get Help?” on page 41.

## Lubricating Joint-1 Encoder Gear – Adept-XL Robot



**CAUTION:** Lubrication of the robot must be performed with PA-4 power chassis power turned OFF.

Use the Brake Release button located on the underside of the inner link to release the brake and allow manual quill movement. See section 3.2 on page 62 for instructions on using the Brake Release button.

1. Support the joint 3 quill.
2. Remove the eight M6 x 30 mm screws that attach the electrical bulkhead to the base cover and robot base. Remove and support the electrical bulkhead six inches away from the robot base (see Figure 10-1 on page 224). Ensure that no stress is being applied to the internal robot harness.
3. Apply grease to the entire circumference of the joint 1 encoder gear. Use the brake release button, located on the underside of the inner link, to free up joint 1 and expose the portion of the gear covered by the joint 1 lower damper.



**WARNING:** Impact Hazard

The robot quill shaft will drop when the brakes are released if not properly supported.

4. Install the electrical bulkhead to the base cover and robot base with eight M6 x 30 mm screws.
5. Tighten all screws on the base cover and electrical bulkhead.
6. Remove the joint 3 quill support.

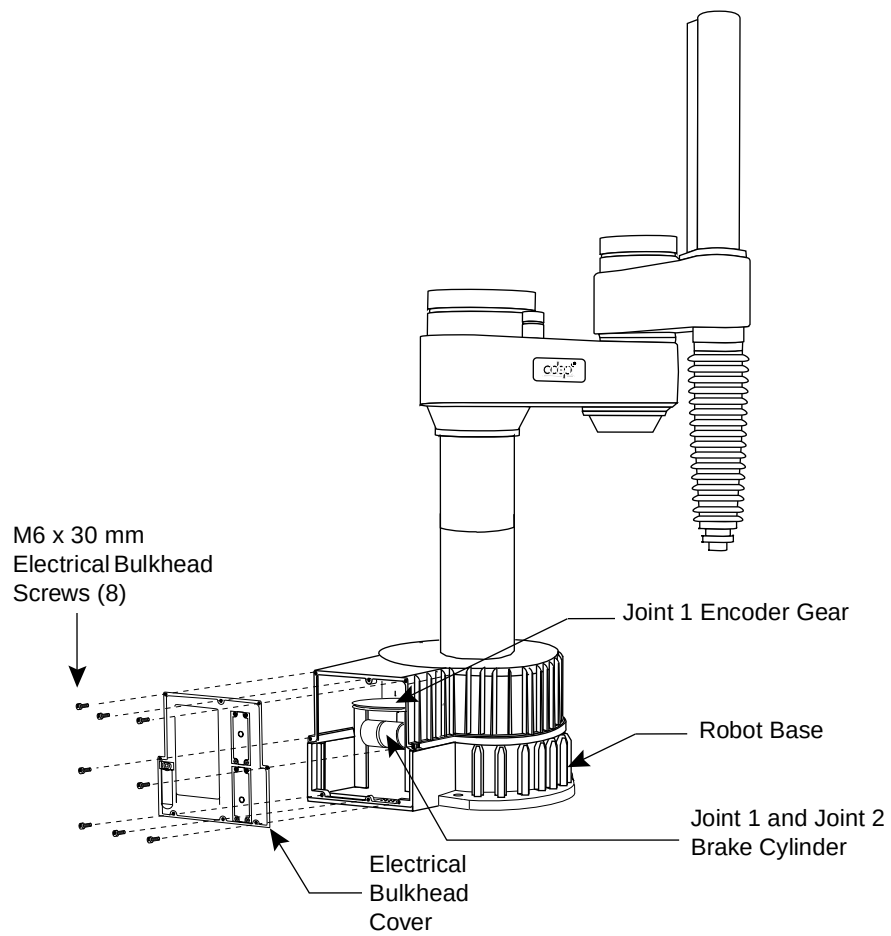


**Figure 10-1. Adept-XL Robot Base Assembly**

## Lubricating Joint 3 Upper Quill Shaft – Adept-XL Robot



**CAUTION:** Lubrication of the robot must be performed with the PA-4 power chassis power turned OFF.

Use the Brake Release button located on the underside of the inner link to release the brake allowing manual quill movement. See section 3.2 on page 62 for instructions on using the Brake Release button.



**CAUTION:** When the brake release button is pressed, the quill (if holding a payload) will drop to the bottom of its travel. To prevent possible damage to the equipment, make sure that the quill is supported while releasing the brake and verify that installed tooling is clear of all obstructions.

1. Turn off power to the PA-4 power chassis.
2. Using an M4 Allen wrench, remove the six socket-head cap screws that hold the quill cover to the outer link. Remove the quill cover. See Figure 10-2 on page 226.
3. Press the Brake Release button and move the quill to its fully retracted or raised position. Inspect the upper quill shaft and remove any excess or accumulated grease with a clean cloth.
4. Apply Mystik® SynGuard™ SX-6™ grease to the axial and spiral grooves on the joint 3 upper quill shaft. Extend and retract the joint 3 quill several times. Inspect the upper quill and wipe off any excess lubricant with a clean, soft cloth.

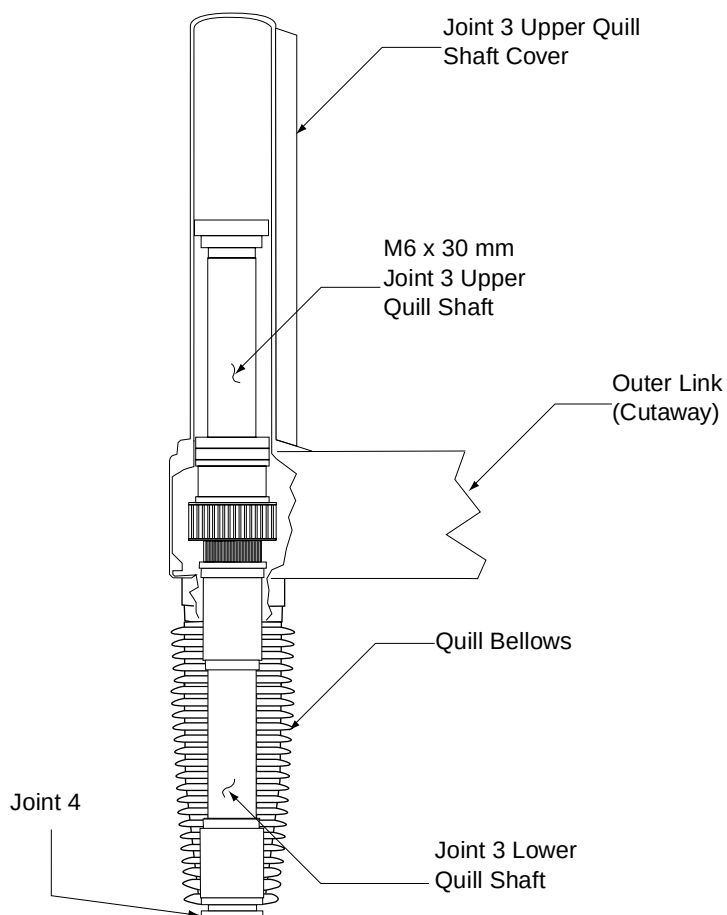


**Figure 10-2. Adept-XL Robot Upper and Lower Quill Shafts**



**CAUTION:** When reinstalling the quill cover of an Adept-XL IP54 Robot, you must reseal the bolts that secure the cover. Refer to the procedure in section 10.7 on page 234 for complete details.

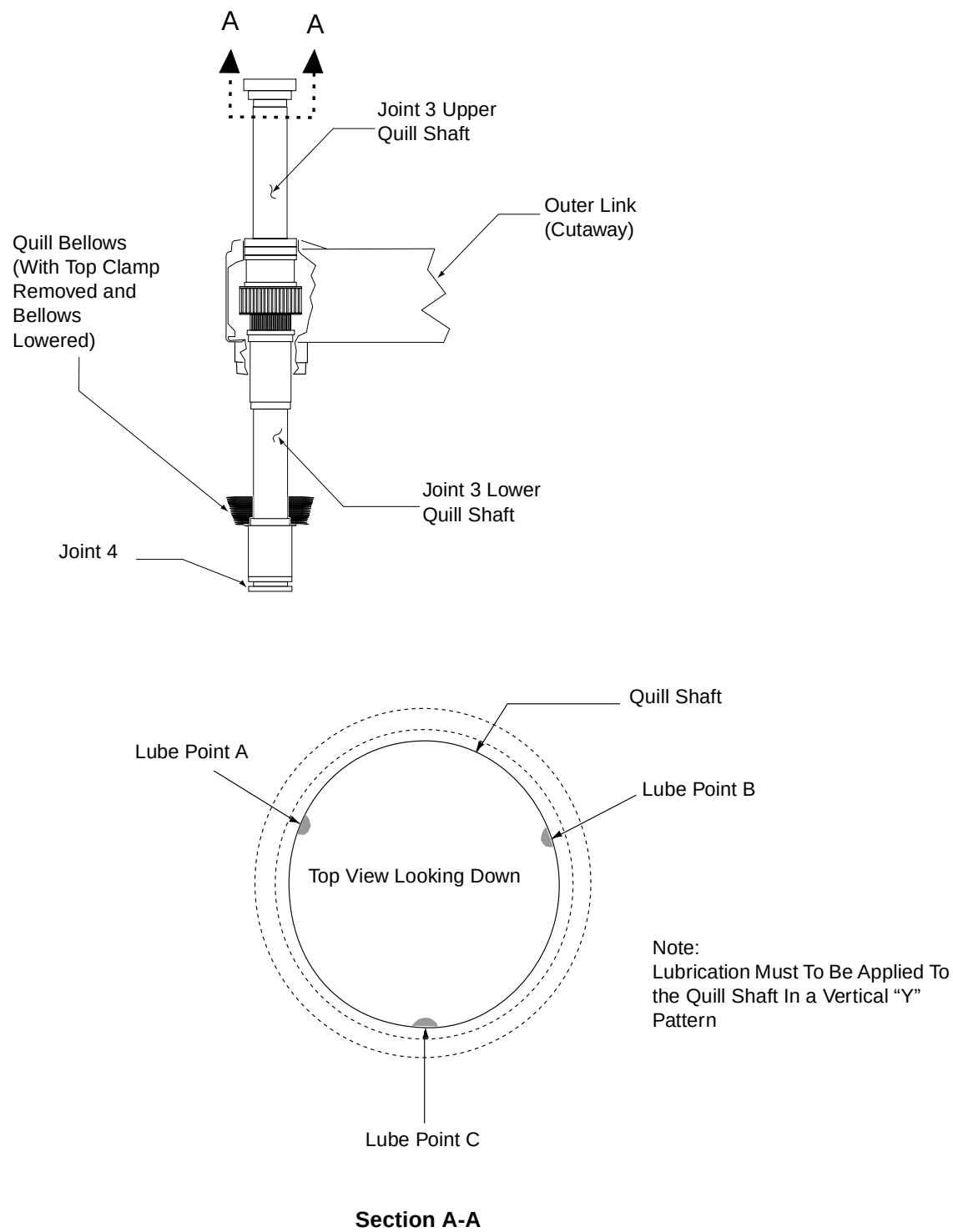


Figure 10-3. Joint 3 Upper Quill Shaft Lubrication

## Lubricating Joint-3 Lower Quill Shaft – Adept-XL Robot

1. Turn off power to the PA-4 power chassis.
2. Move joint 3 to the fully extended (bottom travel) position.
3. Loosen and remove the top clamp on the bellows using a flat-bladed common screw driver. Then slowly and gently pull down on the bellows until the bellows are fully compressed. See Figure 10-3 on page 227.
4. Apply Mystik<sup>®</sup> SynGuard<sup>™</sup> SX-6<sup>™</sup> grease to the axial and spiral grooves on the lower quill shaft.
5. Move joint 3 slowly from the bottom-to-top and top-to-bottom travel positions several times. Then, move joint 3 to a middle-travel position and wipe away any excess grease from the shaft with a clean, soft cloth.
6. Carefully pull bellows up around the lower quill shaft on the outer link. Hold bellows in place and secure the top clamp.
7. Reposition joint 3 to the bottom travel position and install the quill cover. Tighten the six socket-head cap screws with an M5 Allen wrench.

## 10.3 Check Robot Mounting Bolt Tightness

---

The robot mounting bolts (including spool mounting bolts) should be checked periodically to make sure they are not loose. Also check the tightness of all access cover screws and all the captive screws of the cables.

**NOTE:** The Adept-XL robot generates high torque inertia forces.

## 10.4 Maintenance and Inspection of Air Filters

---

### Draining Moisture From Adept-XL Robot Compressed Air Filter

The air filter on the compressed air inlet at the robot base has a moisture trap that should be emptied periodically, depending on the quality of the air supply and the frequency of use. The trap is emptied with the air supply connected. To empty the trap, use a rag to push up on the bottom of the air filter (see Figure 4-14 on page 84). The compressed air filter part number is 30440-03200.

If you have to empty water from the filter housing frequently, check the water content in your compressed air supply and consider using an air dryer. Moisture inside the robot can cause damage to mechanical, electrical, and pneumatic components.

## Adept-XL Robot Fan Filter Inspection and Cleaning

The fan filter on the Adept-XL robot is located on the base; see Figure 4-14 on page 84. The fan filter must be inspected regularly and cleaned at the first sign of dust or dirt buildup. The filter must be inspected and cleaned at least once per month. Regular cleaning will prolong the life of the filter. If the filter becomes clogged or unusable for any reason, you will need to order a new air filter. The part number for the filter is 40320-20232.

1. Turn off power to the PA-4 power chassis.
2. Lift the filter up by the tabs on the top edge.
3. Inspect the filter for dust or dirt particles. If cleaning is required, use compressed air to clean the filter. (Follow all appropriate safety procedures regarding the use of compressed air.)
4. Replace the cleaned air filter.

**NOTE:** A robot equipped with the IP54 option has positive air pressure throughout the interior of the robot. Air is continually being exhausted from under the base of the robot. This means that a cooling fan and filter are not required and are removed when the IP54 option is installed.

## Adept PA-4 Power Chassis Fan Filter Inspection and Cleaning

The air filter located on the front of the chassis should be inspected regularly and cleaned at the first sign of dust or dirt buildup. The filter must be inspected and cleaned at least once per month. Regular cleaning will prolong the life of the filter. If the filter becomes clogged or unusable for any reason, order a new air filter. The PA-4 fan filter part number is 40330-11200.



**WARNING:** Dangerous voltages are present inside the power chassis. Turn off the power to the power chassis and protect it against an unauthorized return to service before opening the front grill to inspect the air filter. Failure to observe this warning could cause injury or damage to your equipment.

1. Turn off the power to the power chassis and protect it against an unauthorized return to service.
2. Open the front grill by loosening two screws and swinging the grill out.
3. Pull the air filter out and inspect for dust or dirt particles. If cleaning is required, use compressed air to clean the filter. (Follow all appropriate safety procedures regarding the use of compressed air.)
4. Replace the cleaned air filter and secure the grill.

## Adept MV Controller Fan Filter Inspection and Cleaning

The air filter located on the front of the chassis should be inspected regularly and cleaned at the first sign of dust or dirt buildup. The filter must be inspected and cleaned at least once per month. Regular cleaning will prolong the life of the filter. If the filter becomes clogged or unusable for any reason, order a new air filter. The Adept MV controller fan filter part number is 40340-00030.



**CAUTION:** If the fan stops working or the filter becomes dirty, the controller could overheat and cause a thermal failure. This applies to all models of Adept MV controllers.

1. Turn off the controller.
2. Loosen the two screws on the fan filter cover to gain access to the filter.
3. Pull the air filter out and inspect for dust or dirt particles. If cleaning is required, use compressed air to clean the filter. (Follow all appropriate safety procedures regarding the use of compressed air.)
4. Replace the cleaned air filter and secure the filter holder.

## **10.5 Changing the Lamp on the CIP High Power Enable Switch**

The system is equipped with circuitry to detect the potentially dangerous condition of a burned out CIP HIGH POWER push button/lamp. If this lamp is burned out, you cannot enable High Power until the lamp has been replaced. To replace the High Power indicator lamp:

1. Turn off the controller and disconnect system power.
2. Remove all cables from the back and side of the CIP.



**WARNING:** Make sure that the cables connected to JDIO1 through JDIO4 are properly labeled. The two input cables can be swapped and the two output cables can be swapped. This could result in a dangerous situation when you restart the controller.

3. Remove the CIP from its mounting location.
4. Remove the seven screws from the front of the CIP, including the MCP bypass plug retaining screw (see Figure 10-4).

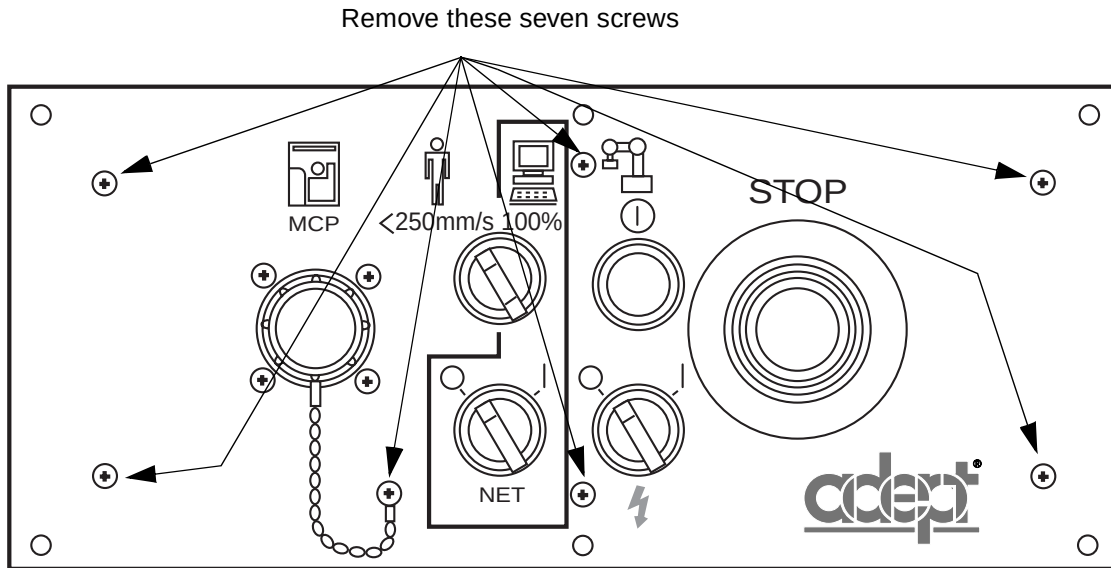


**Figure 10-4. CIP Front Panel Screws**

5. Carefully pull the front panel away from the body of the CIP. You will encounter considerable resistance as there are several plug-type connectors that you need to disconnect as you pull the front panel away from the body of the CIP. Pull the front panel as straight away as possible.
6. Locate the lamp body on the back side of the front panel. Turn the lamp body approximately 20 degrees (in either direction) and then pull the lamp body straight back.
7. Ensure that the lamp body is now free. Remove the old lamp and insert a new lamp.
8. Replace the lamp body by pushing it straight into the lamp housing receptacle. Make sure the contacts on the lamp body are properly oriented (see Figure 10-5).

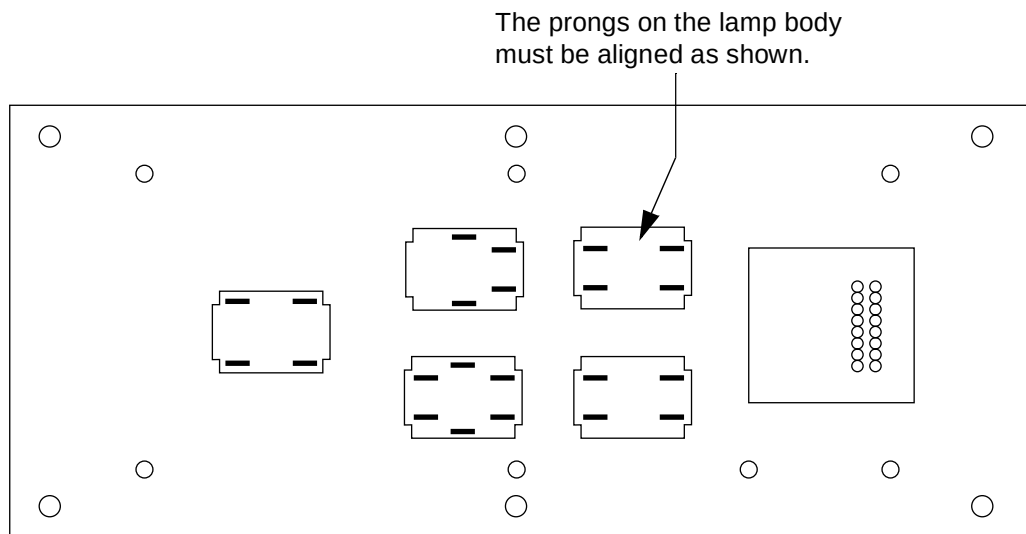


**Figure 10-5. Lamp Body Contact Alignment**

9. Push the CIP front panel into the CIP body, taking care to align all of the plug-type connectors.
10. Replace the six front panel screws and the MCP bypass plug retainer screw.
11. Reinstall the CIP in its mounting.
12. Reconnect the CIP cables. Ensure that the JDIO1 through JDIO4 cables are correctly reinstalled.

## 10.6 Controller Fuse Information

The two fuses (F1 and F2) at the power entry board on the front panel are for the incoming AC power lines. See Table 10-2 for ratings.



**WARNING:** Only skilled or instructed personnel should attempt to change any fuses. Always replace blown fuses with new fuses of the same type and rating.

To remove the fuse holder:

1. Turn off AC power to the controller and disconnect the power cord from the AC power source.
2. Remove the AC power cord from the socket on the power entry board.
3. To remove the fuse holder, insert a small flat-blade screwdriver into the slot between the fuse holder and the power cord socket, then lift up to release the fuse holder; see Figure 10-6. Spare fuses are stored in the sliding compartments.
4. To reinstall the fuse holder, insert it in place, then press down firmly until the entire holder snaps into position.

**Table 10-2. Adept MV Controller Fuse Ratings**

| Fuse                                   | Rating     | Type                       |
|----------------------------------------|------------|----------------------------|
| F1 – AC Line fuse at Power Entry board | 5 AT/250 V | IEC 127-style<br>5 x 20 mm |
| F2 – AC Line fuse at Power Entry board | 5 AT/250 V | IEC 127-style<br>5 x 20 mm |

**NOTE:** The “T” suffix indicates the fuse response time; a 5 AT fuse rating specifies a 5 amp “slow blow” type.

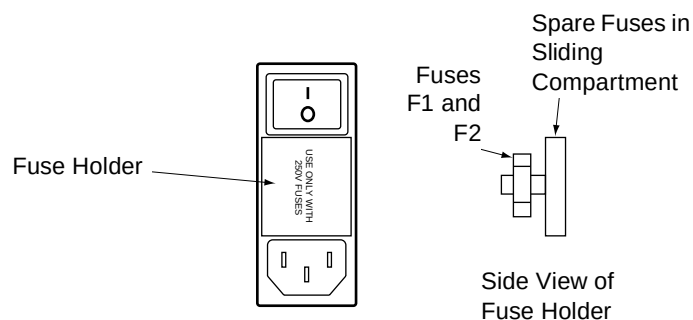


**Figure 10-6. Adept MV Controller Fuse Holder**

## 10.7 Special Maintenance for Adept-XL IP 54 Robot

### Rotary Seal Assemblies

The joint 1 drive tube rotary seal assembly used on the Adept-XL IP 54 Robot is composed of a V-ring Nitrile rubber seal that is in contact with the machined upper base cover. The seal has a clamp that secures the seal to the joint 1 drive tube and acts as a shield against water and dust intrusion. This rotary seal assembly is lubricated at the factory with an O-ring lubricant. During the initial wear-in period, some dry seal particles or seal wear particles mixed with grease may extrude from the seal-to-cover interface. The seal should be checked every three months for signs of excessive wear or breakdown of the nitrile rubber.

### Fixed Seals

The removable access covers are sealed with custom Nitrile rubber gaskets. If these seals degrade or become worn due to physical abuse, chemical attack, etc., they should be repaired or replaced immediately. Please contact Adept Customer Service for further information (see “How Can I Get Help?” on page 41).

## Cleaning Information

The Adept-XL IP 54 robot meets IP 54 requirements for dust and low pressure water splashing. High pressure water nozzles should not be used on the Adept-XL IP 54 robot. If high pressure water nozzles are used near the Adept-XL IP 54 robot, install a protective cover to protect the robot against direct high-pressure spraying. To maintain the robot warranty, follow the procedures listed below and pay close attention to the caution messages.

### Removing the End-Effector for Cleaning

The end-effector can be removed for a separate cleaning procedure (refer to the instructions that come from the manufacturer of the end-effector). When the end-effector is removed, you must either plug the end of the quill so that no moisture can enter the robot or positively pressurize the robot.

### Cleaning Procedure



**CAUTION:** Applying strong alkaline, acidic, or high chlorine cleaning chemicals may degrade the Adept-XL IP 54 robot's surface finish. Cleaning with high pressure sprays, abrasive cleaning agents, or scouring pads is not recommended on the Adept-XL IP 54 robot.

The Adept warranty does not cover damage to seals, the surface finish, or consequential damage caused by failure to observe recommended cleaning procedures and cautions.



**WARNING:** Personnel working in the robot workcell must always wear safety equipment; see section 1.13 on page 40.

1. With High Power turned on, lower the quill to its fully extended position so the bellows folds are as open as possible.
2. Turn off AC power to the power chassis.

**NOTE:** Make sure the robot remains positively pressurized so the internal air flow can work to dry out any internal condensation that may develop during cleaning.

3. Adept recommends that the robot be washed by hand using sponges, towels, or soft brushes and mild detergents or sanitation chemicals.
4. Rinse the robot with a low pressure (0.06 Bar, 10 liters/minute) water hose, typical of a garden hose output.
5. Inspect the bellows, the outer exposed edges of all gaskets, and the rotary seal areas after every cleaning to look for signs of wear, chafing, abrasion, or other indications of problems.

### Drying Time Before Operation

Allow the Adept-XL IP 54 robot to dry for 15 minutes before returning to operation.

### Bolt Removal /Resealing Procedure – Adept-XL IP 54 Robot

The access cover bolts and screws on the inner and outer links of the Adept-XL IP 54 robot are sealed at the factory to prevent moisture entering the robot, as well as to avoid a crevice or depression. If any bolts are loosened or removed, they must be resealed according to the procedure listed below.

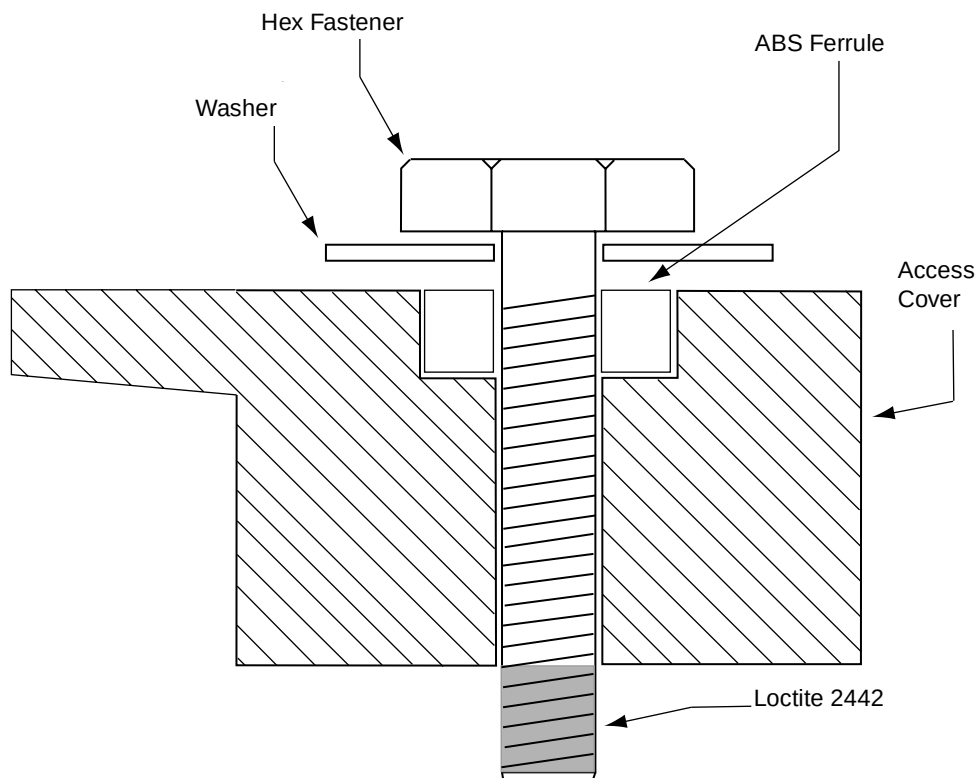


**Figure 10-7. Adept-XL IP 54 Robot Bolt Resealing Detail**

1. Apply a thin coat of Loctite 242 to the bolt threads.
2. Tighten and torque the M5 bolt to 3.4 N•m (30 in-lb).

## 10.8 Adept-XL Clean Room Robot Bellows Replacement

The quill Nitrile bellows should be visually inspected for wear every month. If any signs of wear are visible, the bellows should be replaced.

The procedure below outlines the replacement of the bellows.

### Required Materials and Tools

To perform this procedure you will need the following tools, parts, and materials:

1. Bellows, used for both 8-inch and 14-inch Adept-XL robots (P/N 40861-42010)
2. Medium size flat-bladed screw driver

### Removing the Bellows

Position the robot in an area that allows access to the outer link area. Move joint 3 midway between the hard stops. Disable High Power to the robot. Switch off the On/Off power switch on the Adept MV controller and the Adept PA-4 power chassis.

Refer to Figure 10-8 on page 237 while performing this procedure. Loosen the top bellows clamp and slide it out of the way. Pull the top of the bellows down and away from the outer link housing.

Remove the lower bellows clamp. Carefully pull the bellows off the bearing.

### Installing the New Bellows

Place the top bellows clamp around the top cuff of the bellows. Carefully slide the bellows up and over the exposed quill. Place the smaller end of the bellows over the outer race of the user flange bearing. Clamp the bellows onto the bearing using the bottom bellows clamp.

Put your fingers between the first and second of the top convolutions and push the top bellows cuff up and around the clamping diameter of the outer link housing. It must wrap smoothly around the diameter. Tighten the clamp around the bellows cuff. The bellows cuff must make full contact with the clamping diameter.

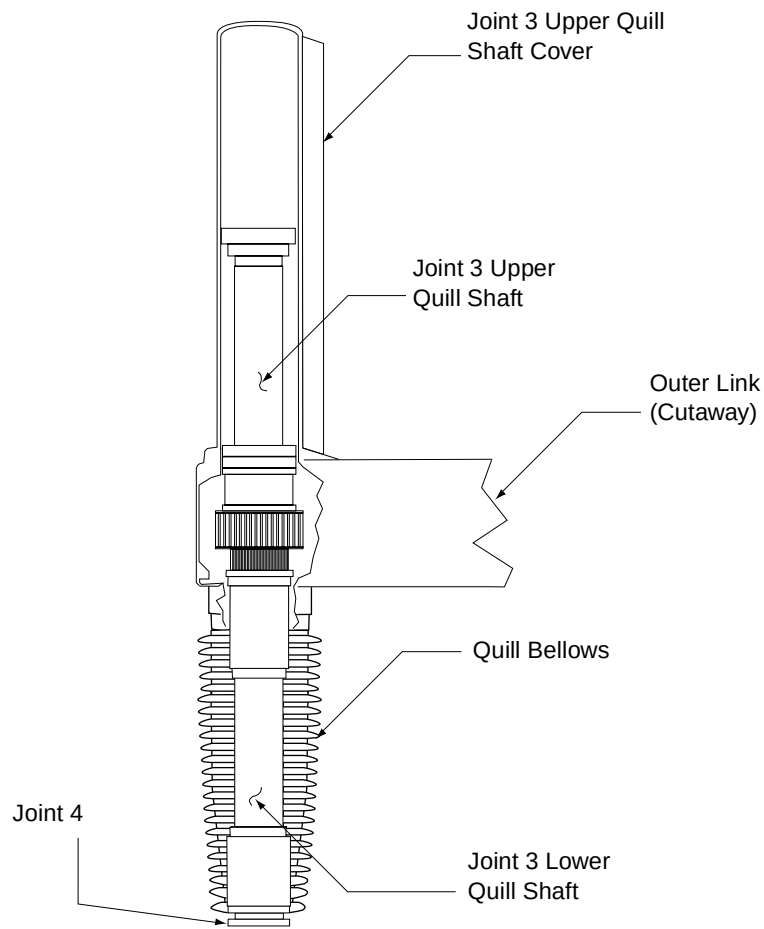


**Figure 10-8. Adept-XL Quill Bellows**

### Further Instructions

The vacuum must now be tested; refer to “Testing the Vacuum” on page 272. If the vacuum test fails, check the bellows for leaks and correct them if found.

After the vacuum has been tested, the end-of-arm tooling can be put back in place and the robot can be returned to normal use.

## 10.9 PA-4 Power Chassis Circuit Breaker and Fuse Information

**NOTE:** The SSER, LVON, HPON, and ILMT labels on the lower right corner of the front of the power chassis are for diagnostic LEDs that can be viewed behind the front grill. These LEDs are for Adept Field Service use only.

### Chassis Circuit Breaker

The power chassis circuit breaker is rated at 15A, and is located on the lower-left front of the chassis, on the power entry module. It also functions as an on/off switch to isolate the chassis.



**CAUTION:** If the circuit breaker trips due to current overload, it indicates an internal fault. Do not reset the circuit breaker yourself: Contact Adept Customer Service (see section 1.18 on page 41 for details on contacting Adept).

### Chassis and Amplifier Module Fuses

Six chassis fuses are located inside the base of the power chassis on the power control board. These fuses are not user-replaceable. If you suspect that a chassis fuse may have blown, contact Customer Service.

In addition to the fuses in the power chassis, there are additional fuses located inside the power amplifier modules. The amplifier fuses are not user-replaceable. If you suspect that an amplifier fuse may have blown, contact Customer Service.



**CAUTION:** Failure of a chassis or an amplifier fuse indicates an internal circuit fault which must be corrected before the fuse is replaced. Do not attempt to replace the fuse yourself: Contact Adept Customer Service (see section 1.18 on page 41 for details on contacting Adept).

### Removing and Installing Amplifier Modules

The Adept PA-4 power chassis is shipped from the factory with the amplifier modules installed in the chassis. Any unused slots are filled with blank covers. Normally, you will not need to remove the amplifier modules. If you do need to remove and reinstall a module, follow the instructions below. The four slots in the chassis are not interchangeable: Some slots have special control signals. The amplifier modules are factory-installed in the correct slots. Contact Adept Customer Service if you need to relocate any modules (see section 1.18 on page 41 for details on contacting Adept).



**WARNING:** Do not attempt to install or remove any amplifier modules without first turning off the power to the power chassis and all related external power supplies. Failure to observe this warning could cause injury or damage to your equipment.

### Removing Amplifier Modules

1. Turn off the PA-4 power chassis and the Adept MV controller.
2. Note the location of any cables connected to the module, then disconnect them.
3. Loosen the captive screws at the top and bottom of the module.
4. Using both the top handle and bottom handle, pull the module straight out of the chassis. Remove the module from the chassis and store it in a safe place.



**CAUTION:** Do not expose the amplifier modules to electrostatic discharge (ESD) while you are handling or storing them. Adept recommends using an antistatic ground strap on your wrist when handling modules.

### Installing Amplifier Modules

1. Turn off the PA-4 power chassis and the Adept MV controller.
2. If the slot has a blank panel installed, loosen the captive screws at the top and bottom of the panel and remove it.
3. Verify that the intended slot for the module is ready to accept the module.
4. Align the module with the card guide slots at the top and bottom of the card cage. Slide the module in slowly. Apply straight-forward pressure to the top and bottom handles until it is firmly seated in the rear power connector, and the face of the module is flush with the other modules.
5. Do not use excessive pressure or force to engage the connector. If the board does not properly connect with the rear power connector, remove the module and inspect the connector and guide slots for possible damage or obstructions.
6. Tighten the captive screws at the top and bottom of the module.



**WARNING:** There is an interlock circuit that prevents enabling power if the amp module screws are not tightened securely. This also applies to any blank panel cover(s). There are dangerous voltages present inside the power chassis. Do not attempt to operate without blank panel cover(s) installed in any unused slots.

## 10.10 Spare Parts List: MV-5/MV-10

Part numbers and specifications are subject to change. Contact Adept Customer Service for ordering information for items in Table 10-1 on page 221, or for items not listed (see section 1.18 on page 41).

**Table 10-3. Controller Spare Parts List From Adept**

| Description                            | Adept Part Number | Quantity | General Comments                                                                      |
|----------------------------------------|-------------------|----------|---------------------------------------------------------------------------------------|
| Fan Filter                             | 40340-00030       | 1        |                                                                                       |
| Front Panel Bypass plug                | 10330-01040       | 1        | User can build their own; see the <i>Adept MV Controller User's Guide</i> for details |
| E-Stop test plug, for JSIO port on CIP | 10330-01075       | 1        |                                                                                       |

**Table 10-4. Controller Spare Parts List From Third Parties<sup>a</sup>**

| Description | Specification                    | Quantity | General Comments                   |
|-------------|----------------------------------|----------|------------------------------------|
| Fuse F1     | 5 AT/250V, 5x20mm, IEC 127 style | 1        | AC line fuse at power entry board. |
| Fuse F2     | 5 AT/250V, 5x20mm, IEC 127 style | 1        | AC line fuse at power entry board. |

<sup>a</sup> These items are not available from Adept.

## 10.11 Spare Parts List: PA-4 Amplifier Chassis

Part numbers and specifications are subject to change. Contact Adept Customer Service for ordering information for items in Table 10-5.

**Table 10-5. PA-4 Spare Parts List**

| Description | Adept Part Number | Quantity | General Comments |
|-------------|-------------------|----------|------------------|
| Fan Filter  | 40330-11200       | 1        |                  |

## 10.12 Spare Parts List: Adept-XL Robot

Part numbers and specifications are subject to change. Contact Adept Customer Service for ordering information for items in Table 10-6.

**Table 10-6. IP 54 and Adept-XL Clean Room Robot Spare Parts List**

| Description | Adept Part Number | Quantity | General Comments |
|-------------|-------------------|----------|------------------|
| Gasket Kit  | 90862-00800       | 1        |                  |



# Technical Specifications

# 11

## 11.1 Robot Dimension Drawings

Additional drawings of Adept products in DXF format are available on the Manuals on CD-ROM that ships with each system, and on the Adept Web site, [www.adept.com](http://www.adept.com).

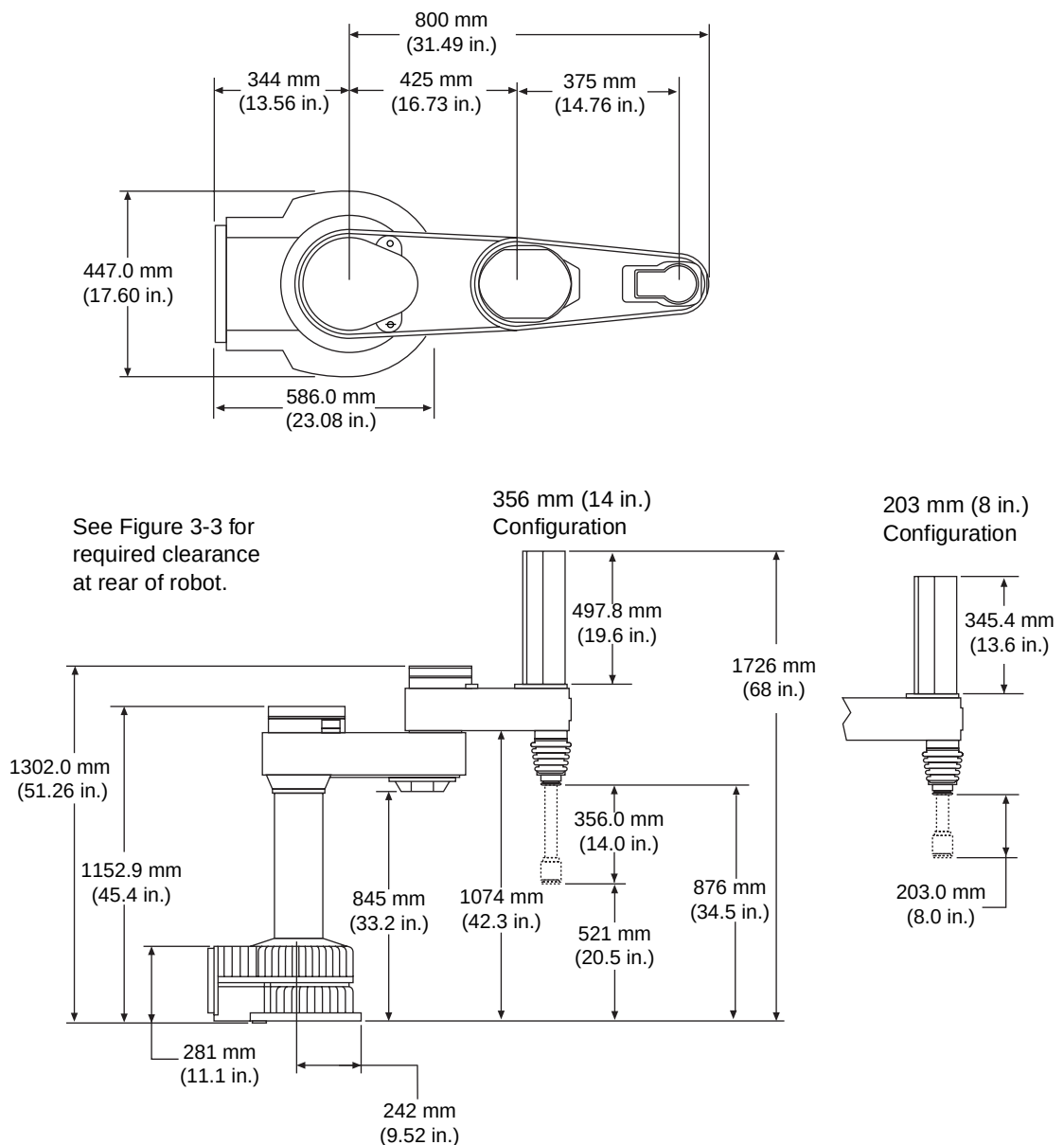


Figure 11-1. AdeptOne-XL Robot Top and Side Dimensions

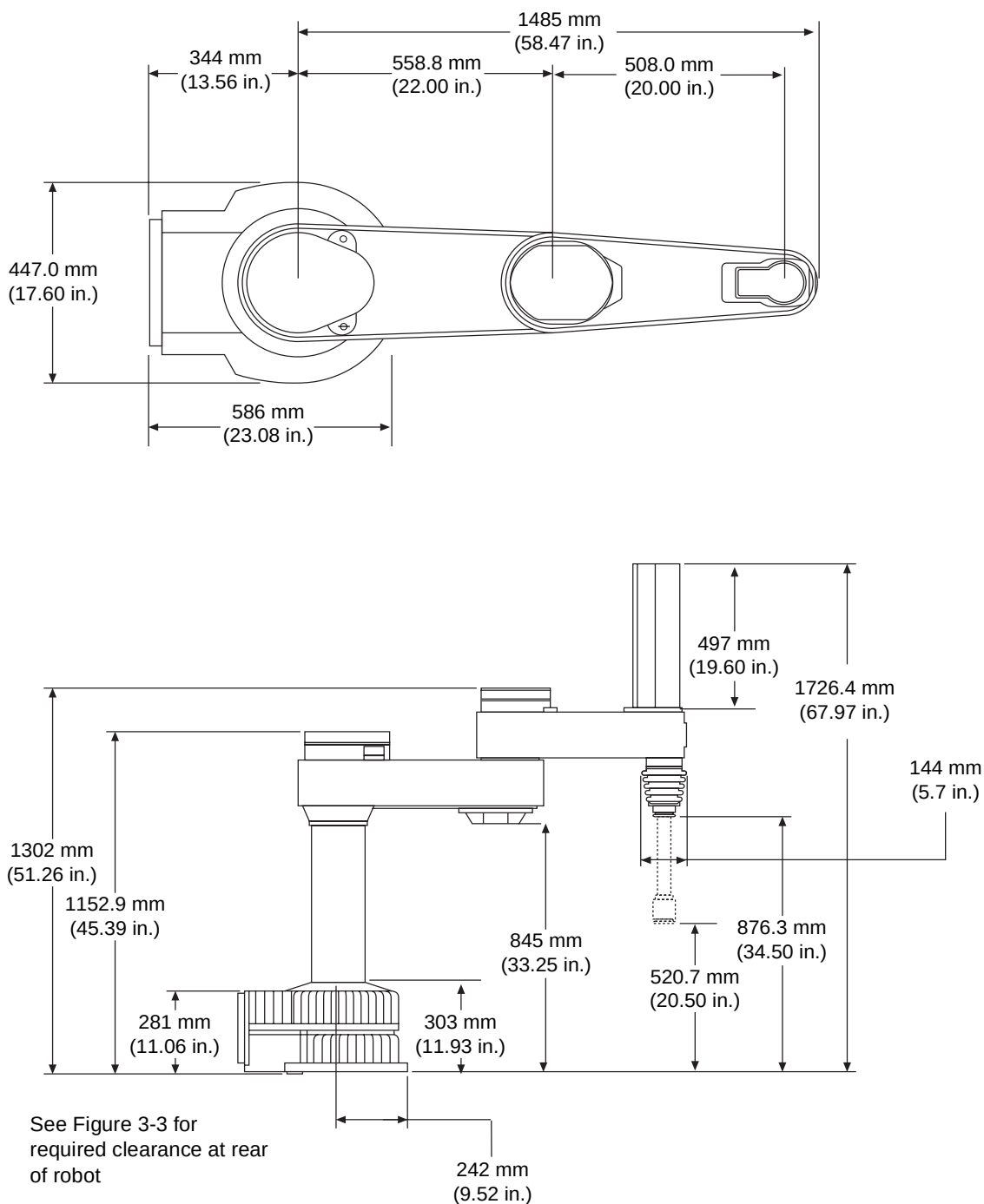


**Figure 11-2. AdeptThree-XL Robot Top and Side Dimensions**

## Customer External Equipment Mounting Area

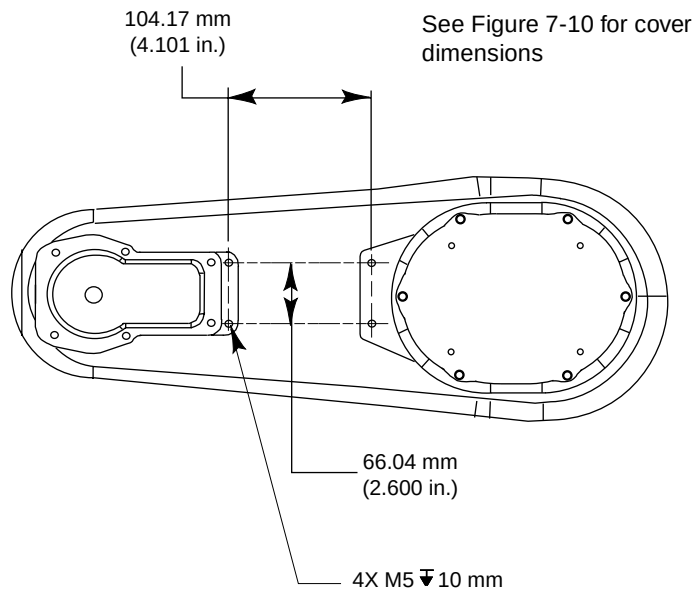


**Figure 11-3. AdeptOne-XL External Equipment Mounting Area**

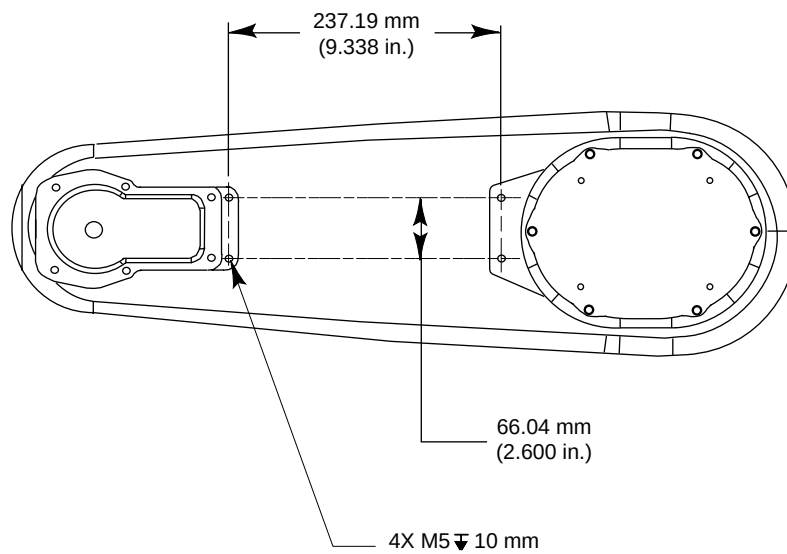


**Figure 11-4. AdeptThree-XL External Equipment Mounting Area**

## Dimensions of the Camera Bracket Mounting Pattern

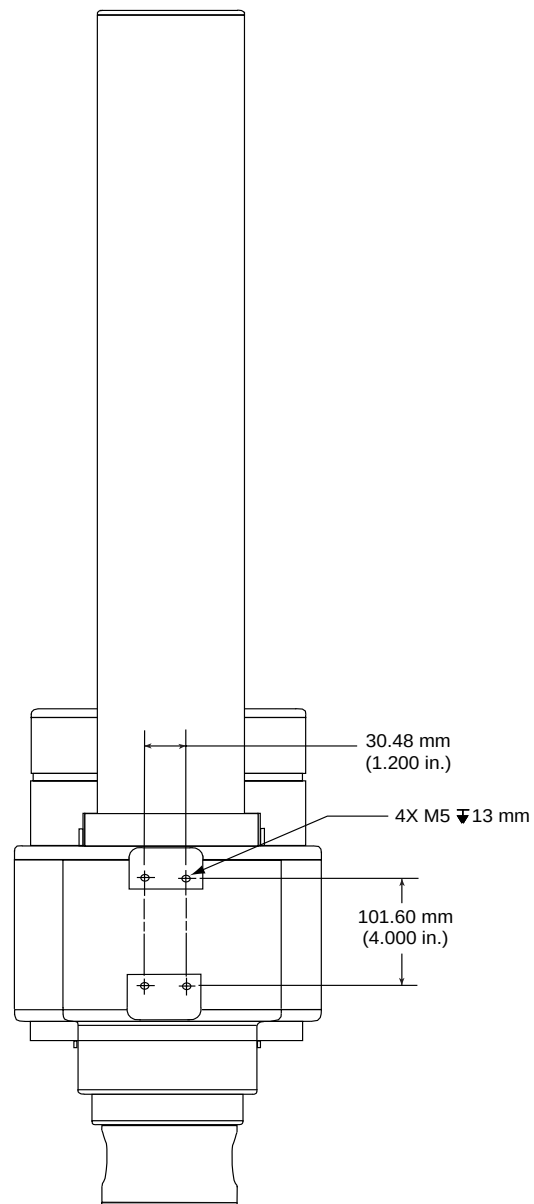


**Figure 11-5. Adept-XL Camera Bracket Mounting Pattern**

## Tool Flange Dimensions of the Adept-XL Robots

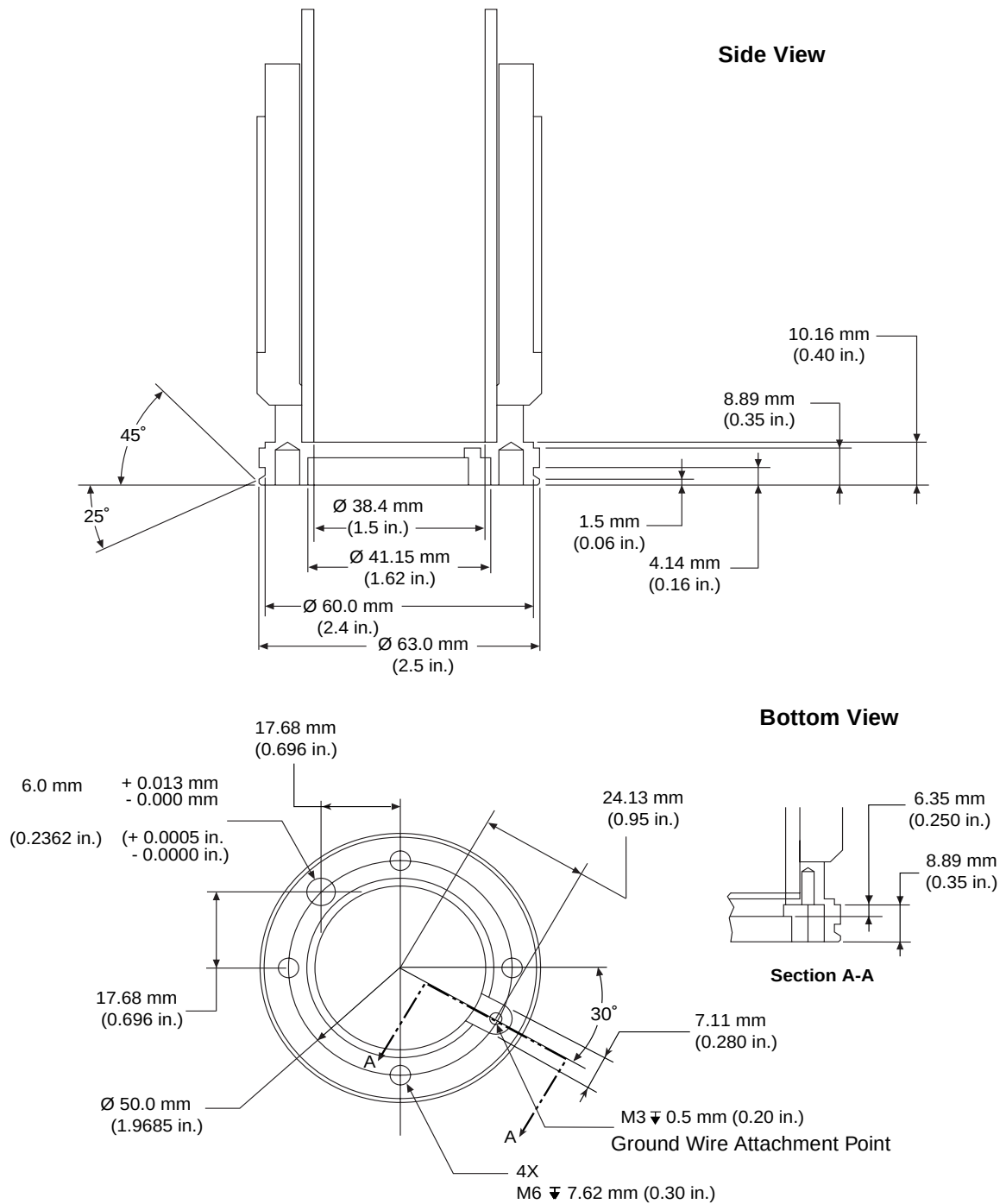


**Figure 11-6. Adept-XL Robot Tool Flange Dimensions**

## Dimensions of the Adept MV-10 and Adept MV-5 Controllers

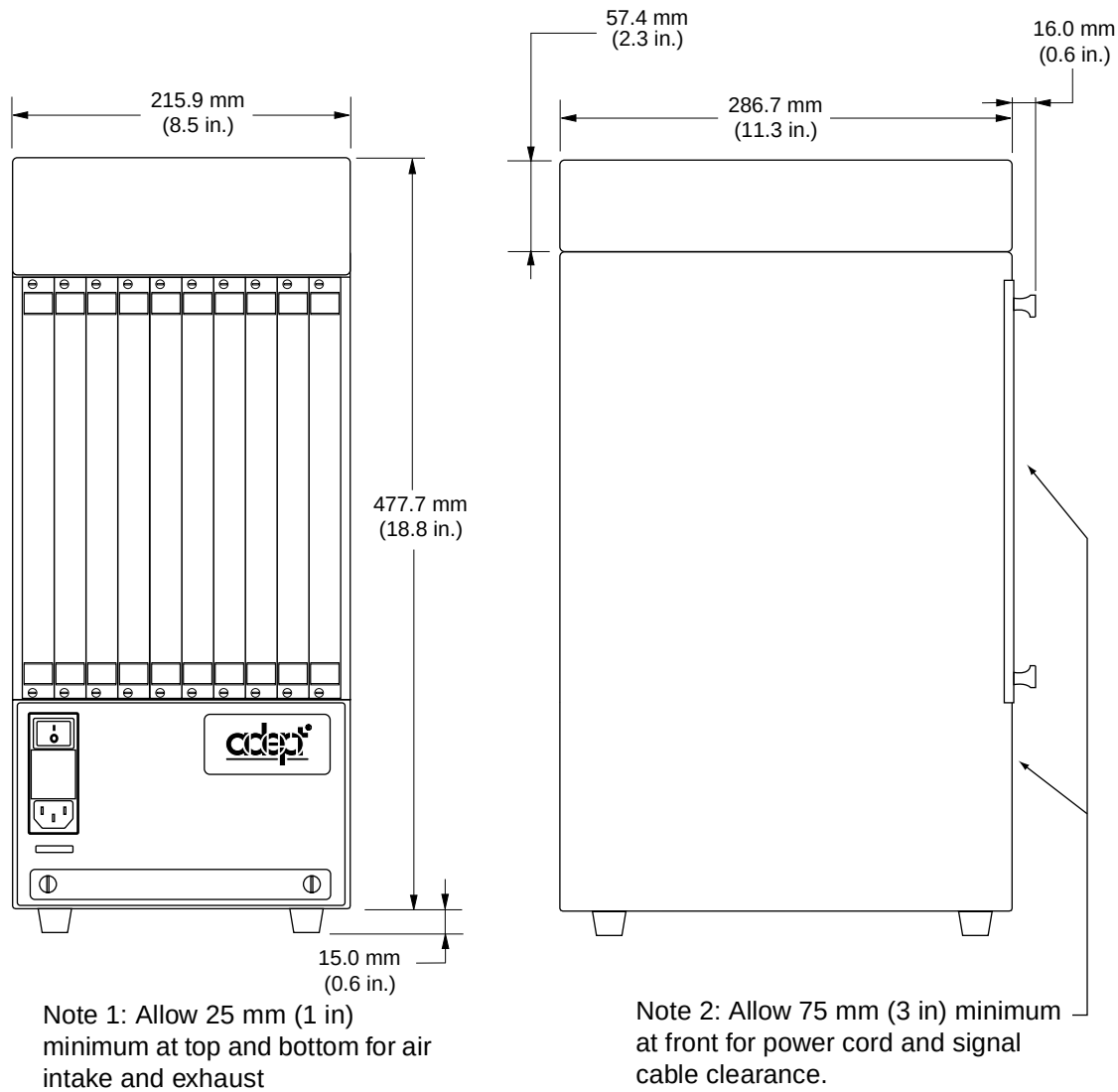


**Figure 11-7. Adept MV-10 and Adept MV-5 Controller Dimensions**

## Dimensions of the Adept PA-4 Power Chassis

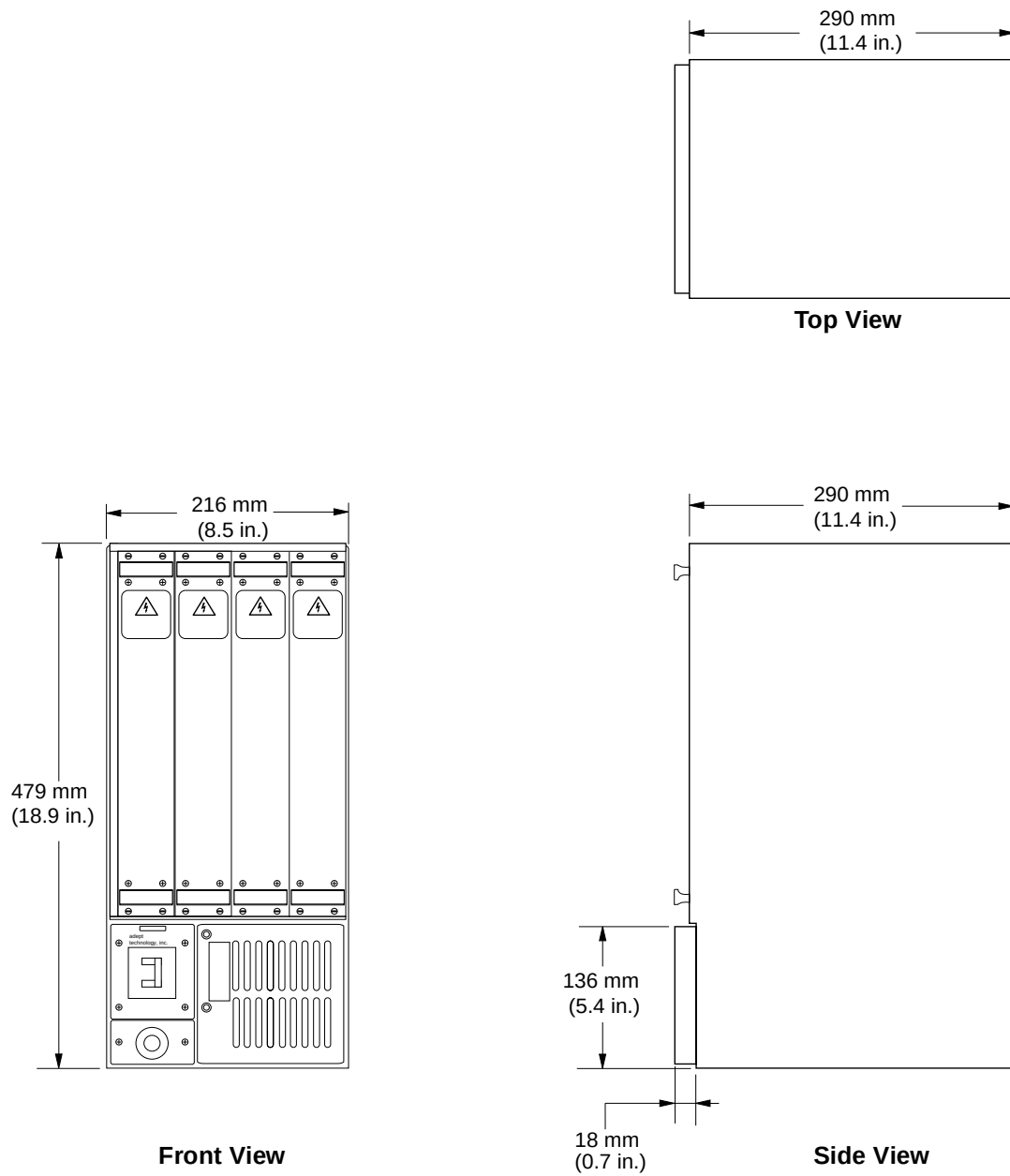


Figure 11-8. Adept PA-4 Power Chassis Dimensions

## Dimensions of the Controller Interface Panel (CIP)

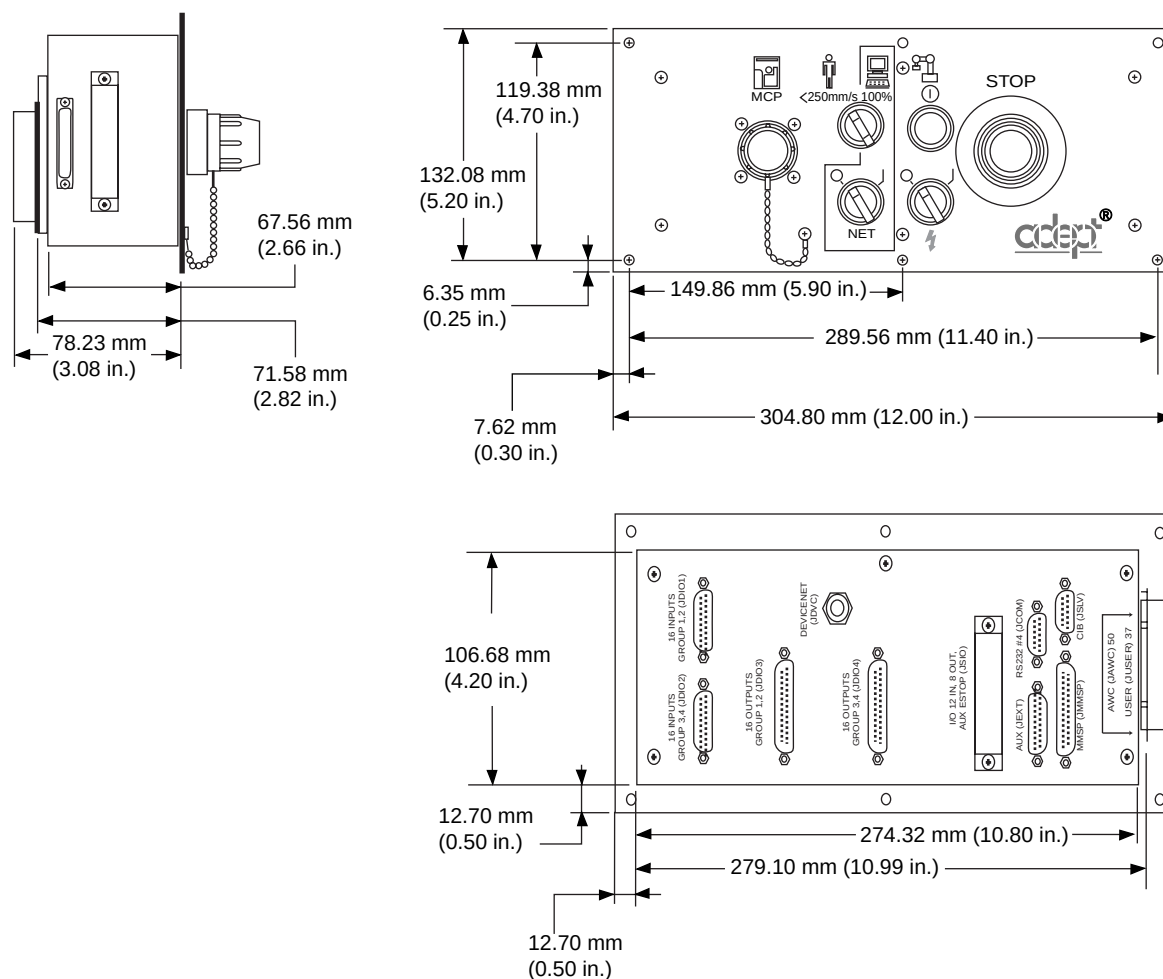


Figure 11-9. Adept Controller Interface Panel (CIP) Dimensions

## Dimensions of the MMSP Security Panel

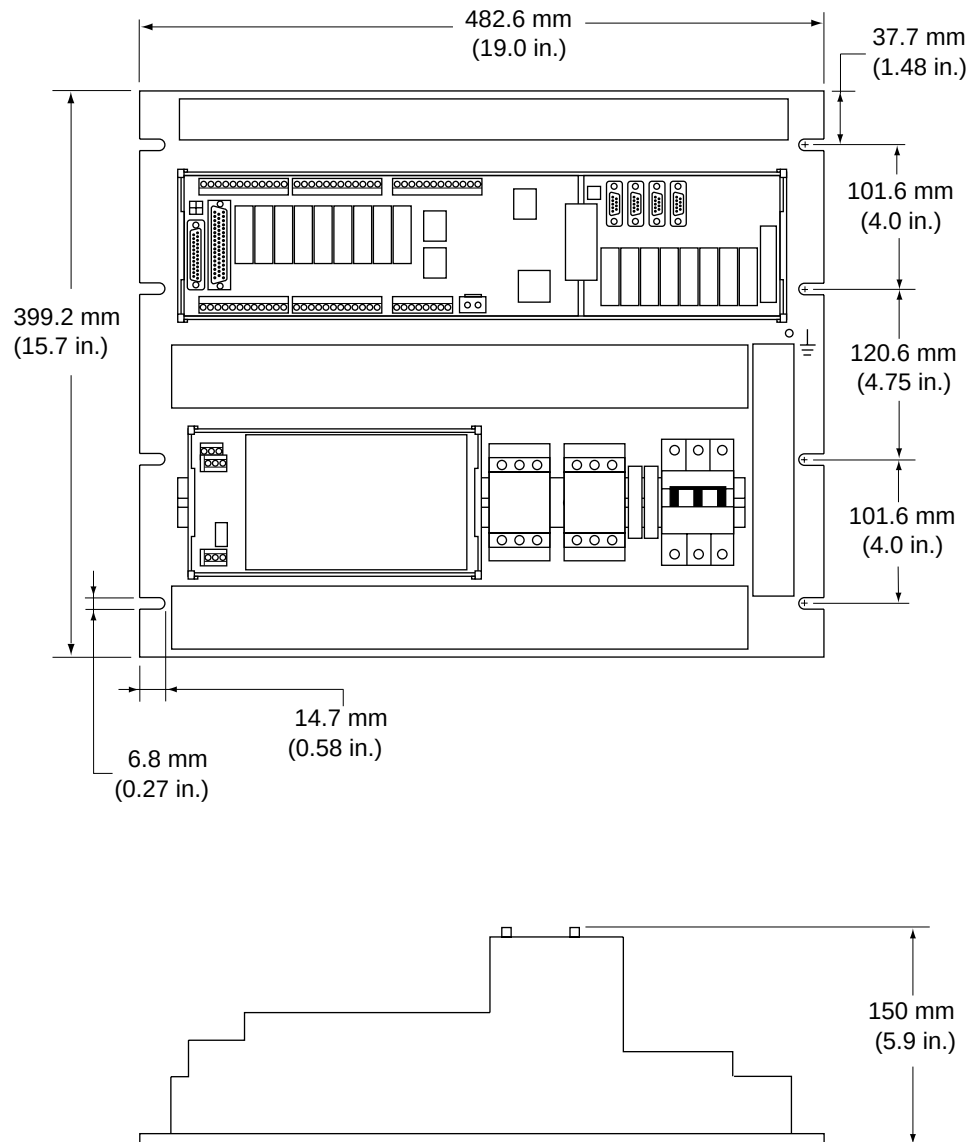


Figure 11-10. MMSP Security Panel Dimensions

## Dimensions of the Controller and PA-4 Mounting Brackets

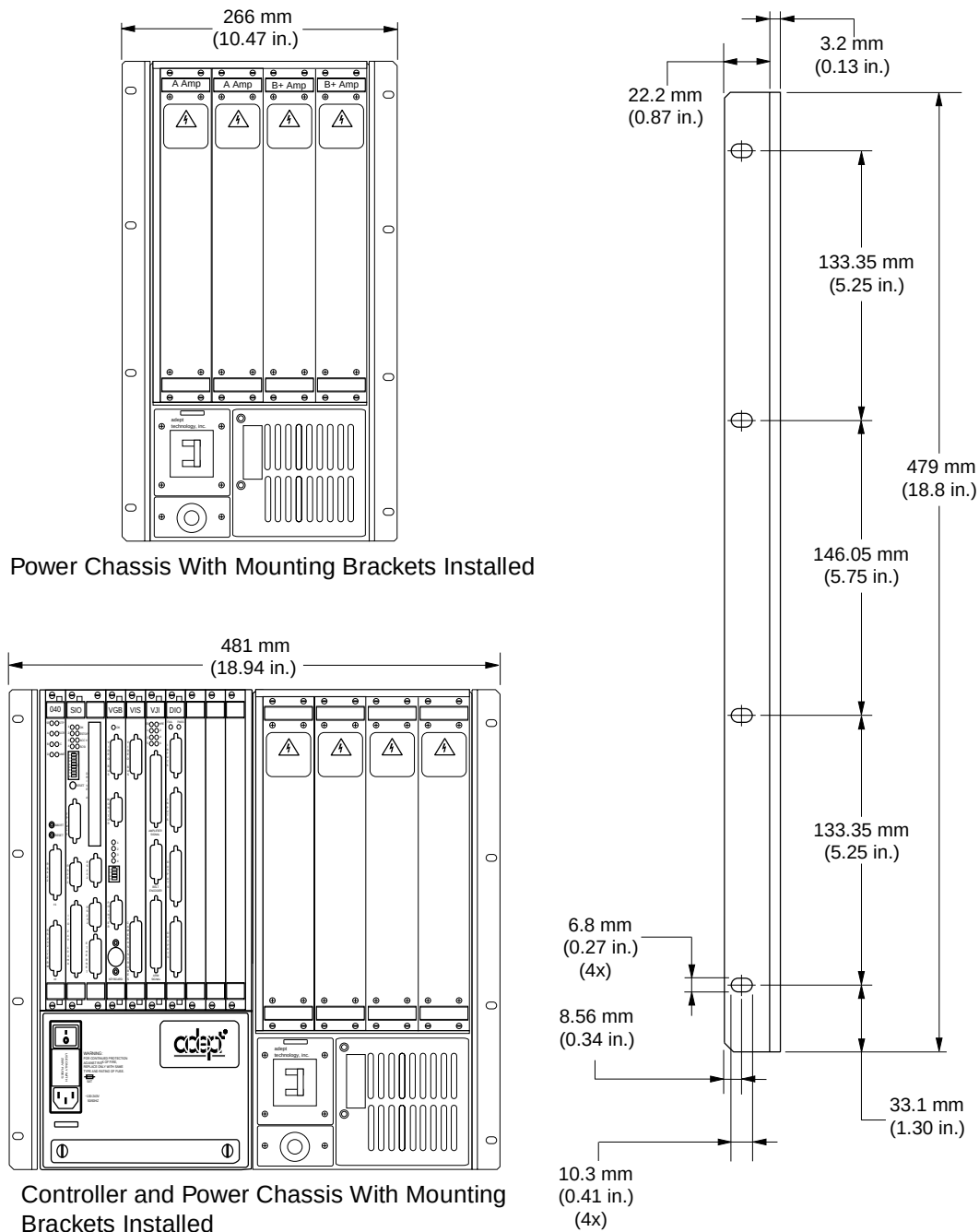


Figure 11-11. Controller and PA-4 Dimensions With Mounting Brackets Installed

## Dimensions of the Manual Control Pendant (MCP)

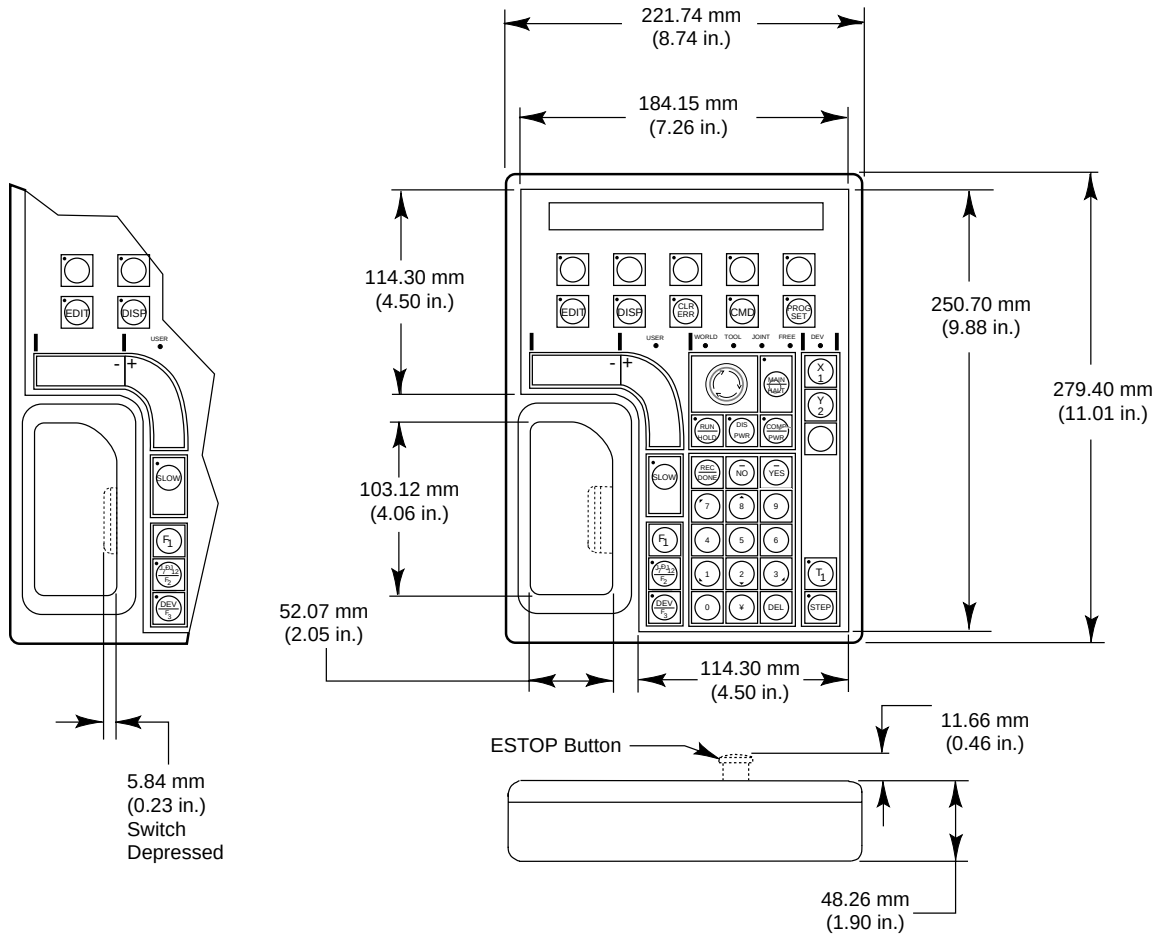


Figure 11-12. Manual Control Pendant (MCP) Dimensions

## Dimensions of the MCP Cradle

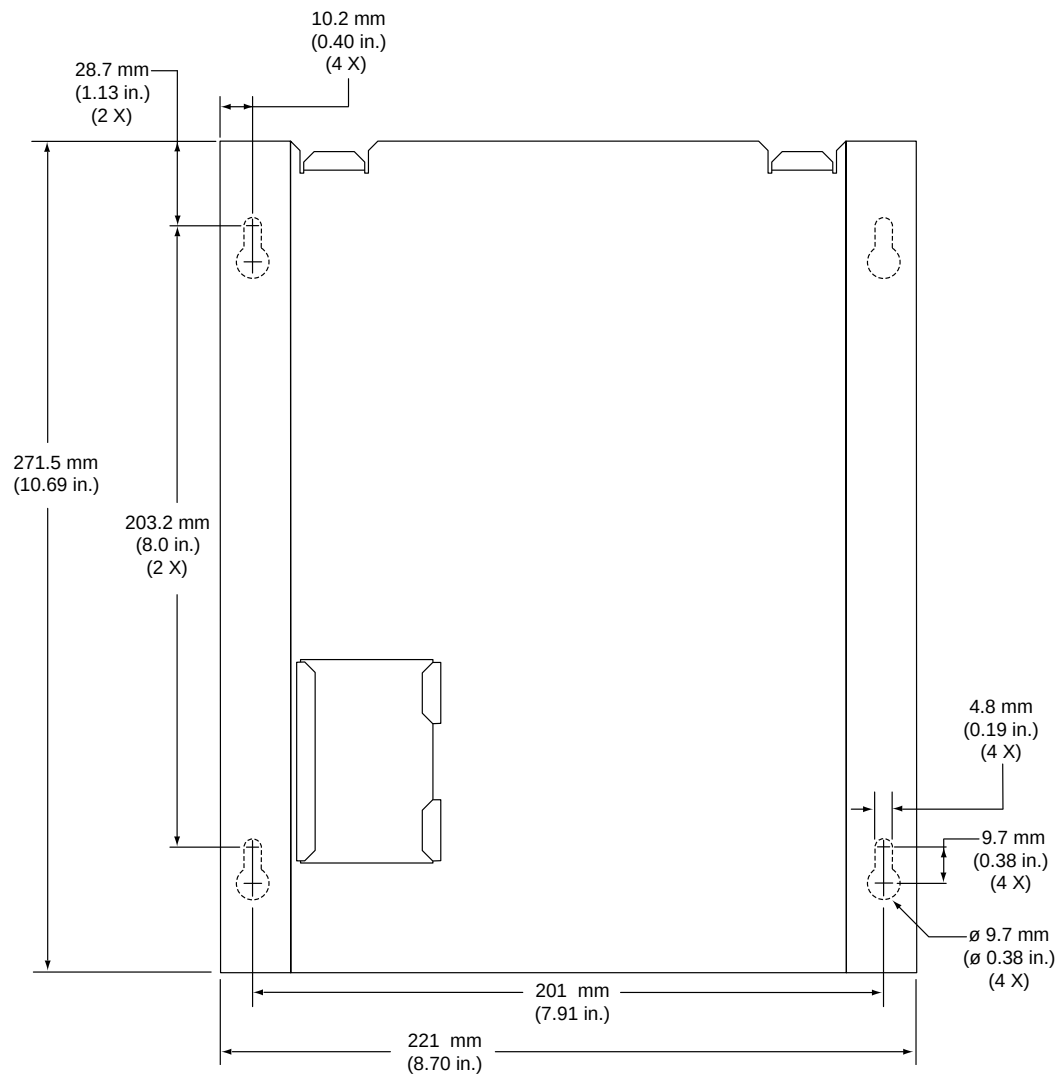


Figure 11-13. MCP Cradle Dimensions

## 11.2 Joint Motions

### AdeptOne-XL Robot Working Envelope

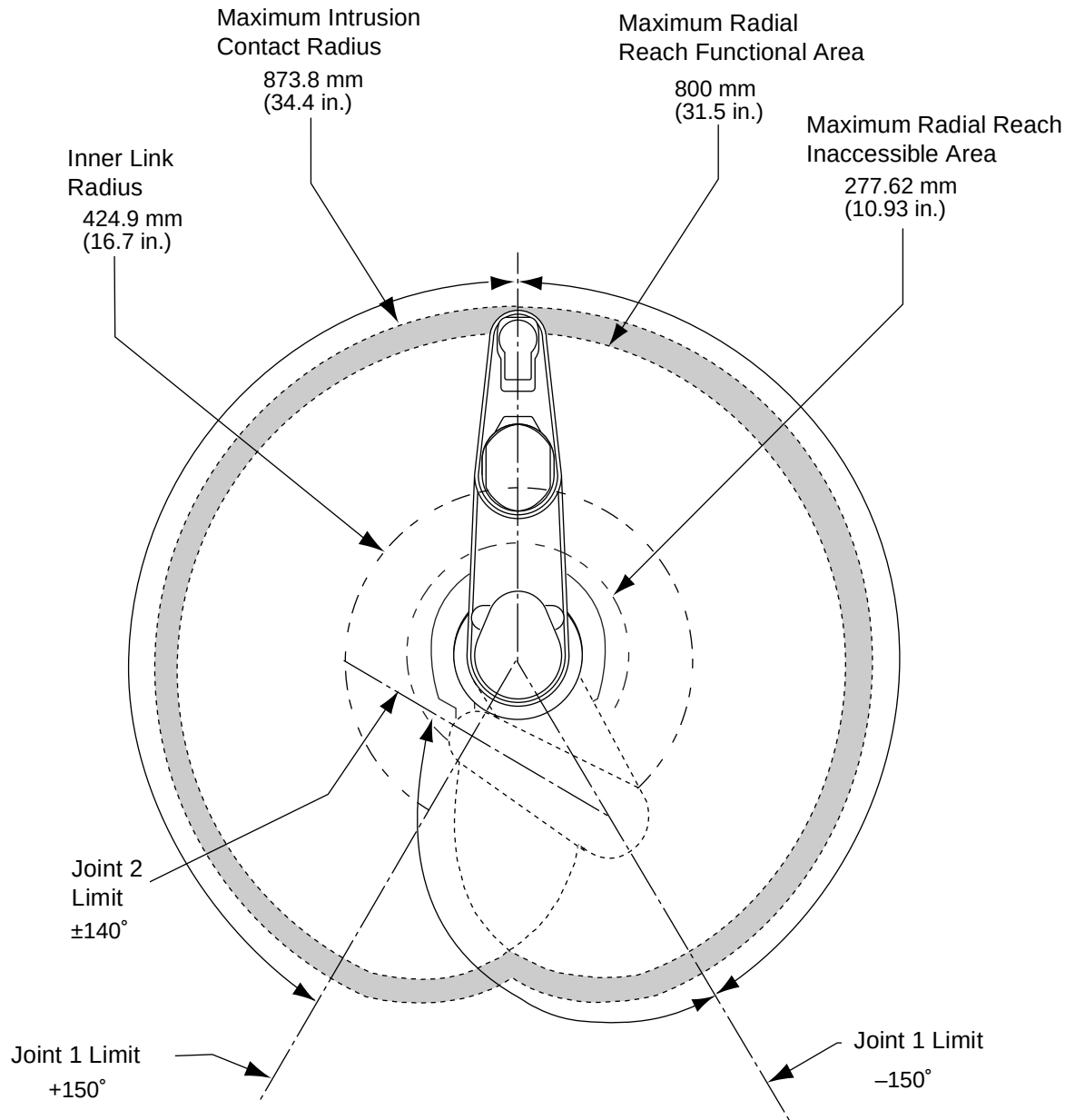


Figure 11-14. AdeptOne-XL Robot Working Envelope

## AdeptThree-XL Robot Working Envelope

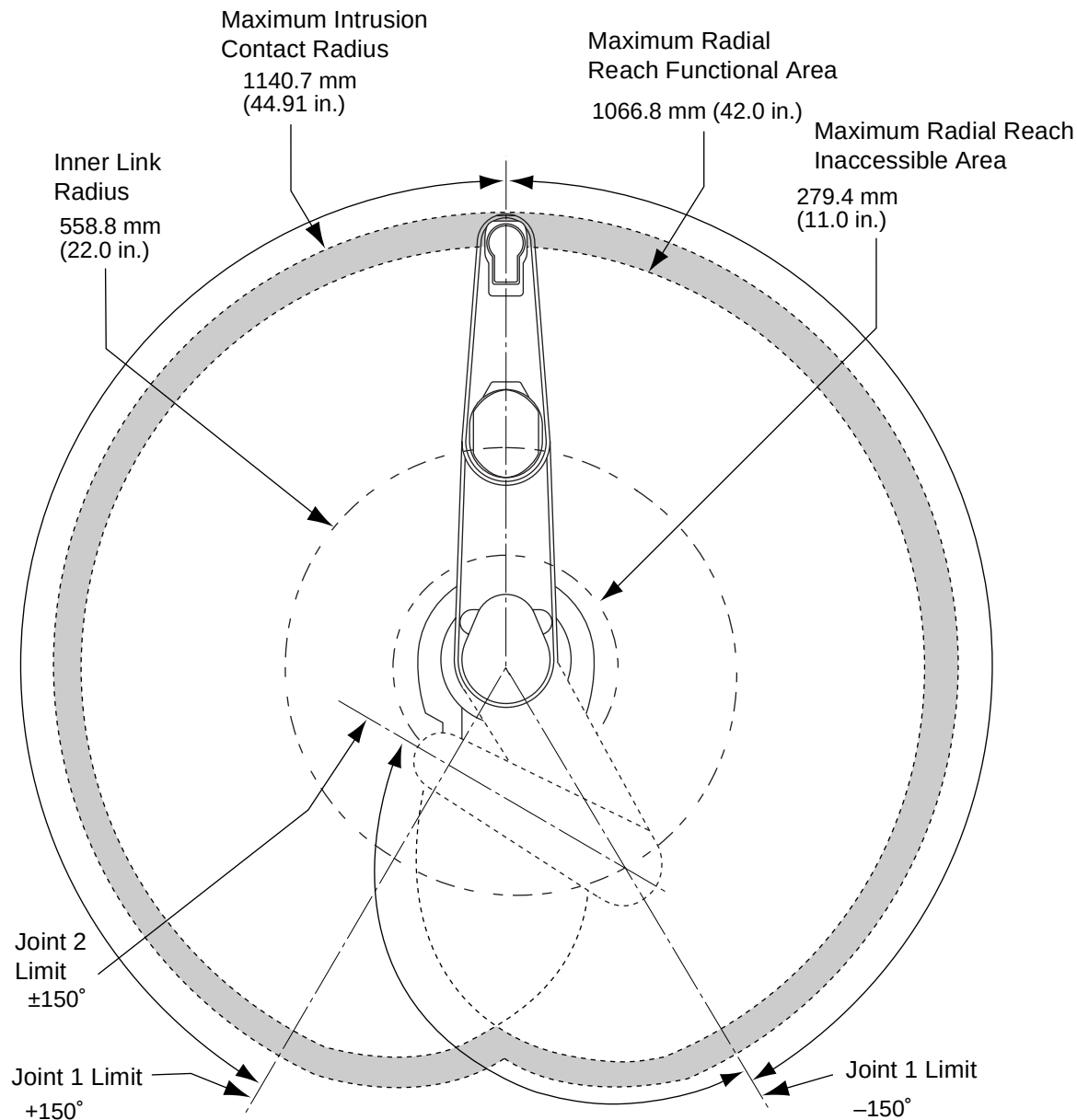


**Figure 11-15. AdeptThree-XL Robot Working Envelope**

### Joint 1

Joint 1, also referred to as the shoulder, provides the rotational movement of the inner link and the column. Travel of the inner link is limited by software to 300 degrees (see Figure 11-16 and Figure 11-17 on page 257).

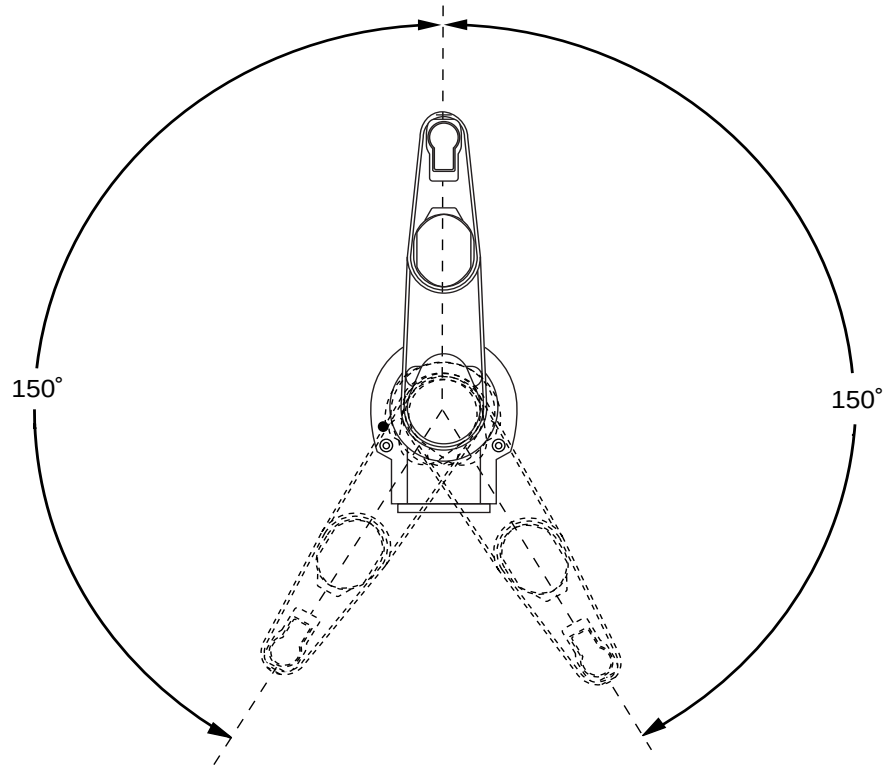


**Figure 11-16. AdeptOne-XL Joint-1 Motion**

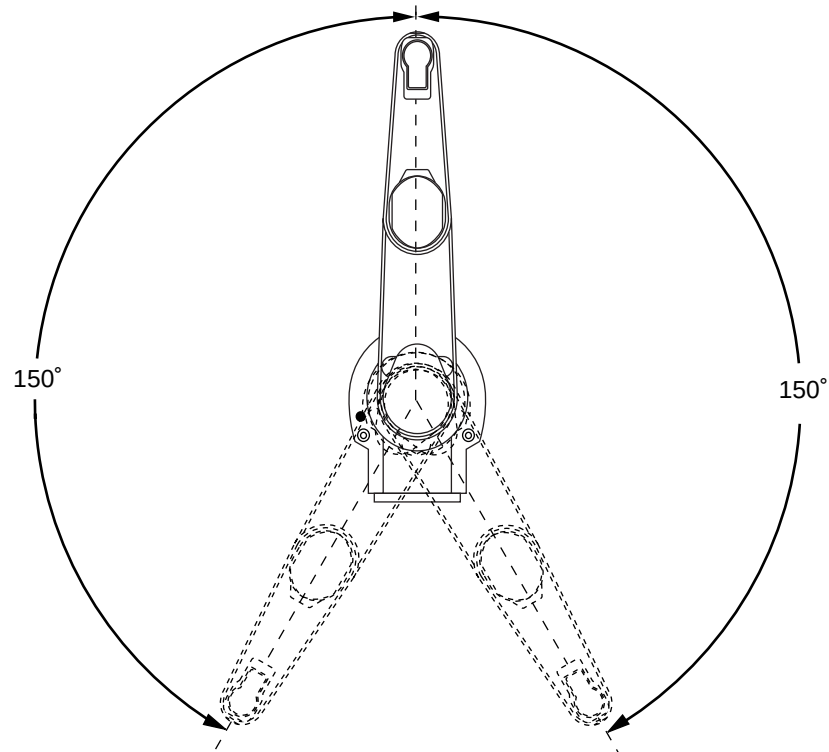


**Figure 11-17. AdeptThree-XL Joint-1 Motion**

## Joint 2

Joint 2, also referred to as the elbow, is the pivot point between the inner link and the outer link. Outer link travel is limited by hardstops located on top of the inner link. Travel of joint 2 is also limited by software to the value set by the softstop. The softstops are set to  $\pm 150$  degrees (AdeptThree-XL) and  $\pm 140$  degrees (AdeptOne-XL) from the zero position (extended straight out). This motion is similar to an elbow that can act in either a left-hand or right-hand configuration (see Figure 11-18 and Figure 11-19).

The robot can reach a given location in either a right-hand (Righty) or left-hand (Lefty) configuration. This configuration is not stored when a location value is saved. When V<sup>+</sup> moves the arm to a location, it might return to that location in either configuration, depending on the starting configuration of the arm. If the robot must always return to a location with a specific configuration, the programmer must specify (within the program) RIGHTY or LEFTY configuration.

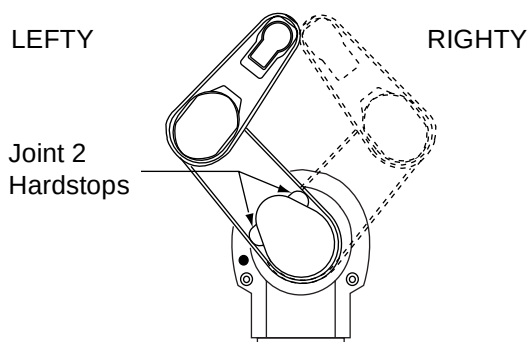


**Figure 11-18. AdeptOne-XL Joint-2 LEFTY/RIGHTY Configurations**

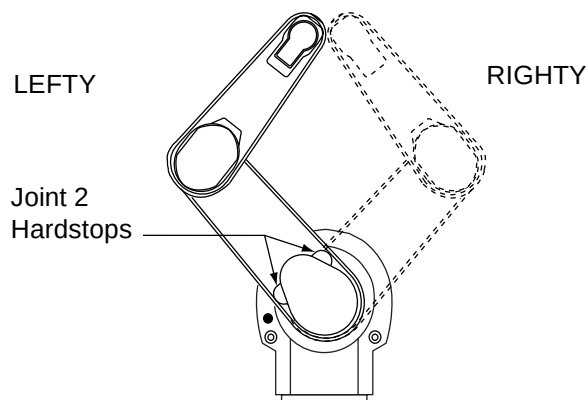


**Figure 11-19. AdeptThree-XL Joint-2 LEFTY/RIGHTY Configurations**

## Joint 3

The AdeptOne-XL robot joint 3 range of motion (see Figure 11-20) is 356 mm (14.0 in.) for the 356 mm quill configuration and 203 mm (8.0 in.) for the 203 mm quill configuration. The AdeptThree-XL robot joint 3 range of motion (see Figure 11-21) is 356 mm (14.0 in.).

## Joint 4

Joint 4, also referred to as the wrist, provides rotation of the quill over a range defined by the softstop. This motion is similar to that of the human hand involved in tightening a bolt or unscrewing a bottle cap (see Figure 11-20 and Figure 11-21). The rotational limit is set by software to plus or minus ( $\pm$ ) 270 degrees from the zero wrist position.

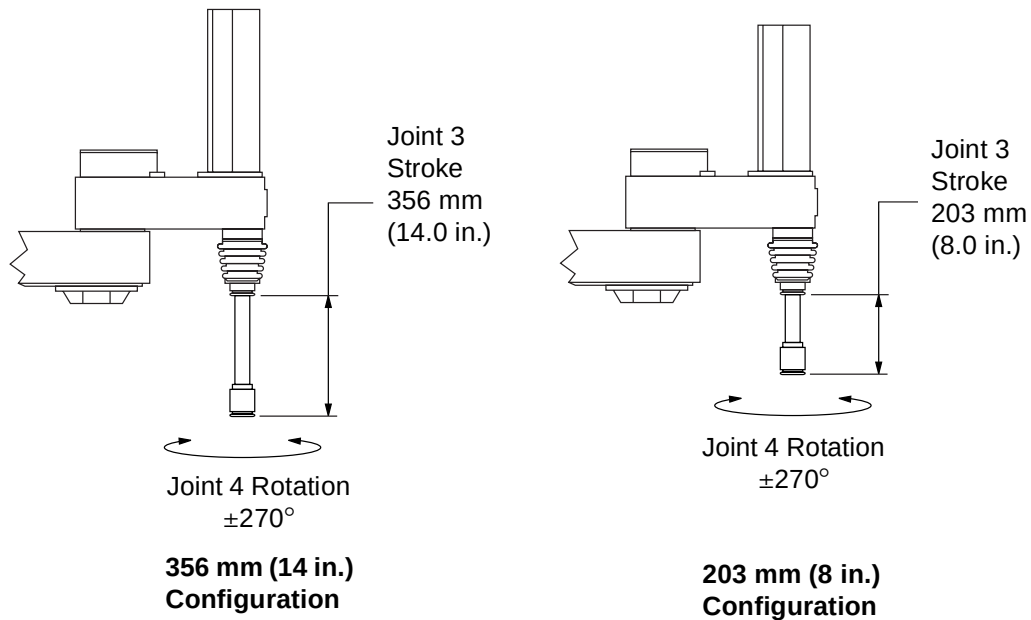


**Figure 11-20. AdeptOne-XL Joint 3 and Joint 4 Motions**

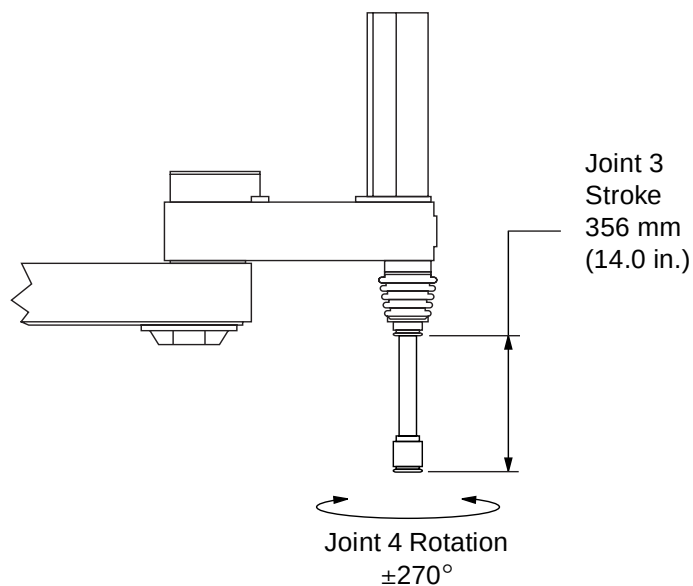


**Figure 11-21. AdeptThree-XL Joint 3 and Joint 4 Motions**



**Table 11-1. AdeptOne-XL Robot Performance Specifications (Continued)**

|                                             |                               |
|---------------------------------------------|-------------------------------|
| <b>Joint Speed (maximum)</b>                |                               |
| Joint 1                                     | 650°/sec                      |
| Joint 2                                     | 920°/sec                      |
| Joint 3                                     | 1000 mm/sec (39.4 in./sec)    |
| Joint 4                                     | 3300°/sec                     |
| <b>Weight</b>                               |                               |
| Robot without options                       | 265 kg (583 lb)               |
|                                             |                               |
| Power chassis, with 3 amplifier modules     | approximately 16.4 kg (36 lb) |
| Adept MV controller, with AWC 040, 060, VGB | approximately 14.5 kg (32 lb) |
| <b>Design Life</b>                          | 120 million production cycles |

<sup>a</sup> Maximum possible running at reduced speed.

<sup>b</sup> The robot tool performs a continuous-path motion consisting of all straight-line segments; 25 mm (1 in.) up, 305 mm (12 in.) over, 25 mm (1 in.) down, and returning along the same path. The endpoints of the cycle are approached in COARSE mode, with a brake at end-point.

**Table 11-2. AdeptOne-XL Robot Softstop and Hardstop Specs**

| Joint                             | Default Softstop             | Hardstop (approximate)                              |
|-----------------------------------|------------------------------|-----------------------------------------------------|
| Joint 1                           | ±150°                        | ±152° (Braketrack) <sup>a</sup><br>±300° (Hardstop) |
| Joint 2                           | ±140°                        | ±142°                                               |
| Joint 3<br>(356 mm Configuration) | 0 to 356 mm<br>(0 to 14 in.) | -6.6mm to 371 mm<br>(-0.26 to 14.6-in.)             |
| Joint 3<br>(203 mm Configuration) | 0 to 203 mm<br>(0 to 8 in.)  | -6.6mm to 218 mm<br>(-0.26 to 8.6-in.)              |
| Joint 4                           | ±270°                        | None                                                |

<sup>a</sup> In between the softstop and hardstop, Joint 1 has a braketrack. An internal proximity sensor will cause a V<sup>+</sup> error condition and shut down High Power to the robot if the braketrack area is entered.

## 11.4 AdeptThree-XL Robot Specifications

All specifications subject to change without notice.

**Table 11-3. AdeptThree-XL Robot Performance Specifications**

|                                                            |                                                      |           |
|------------------------------------------------------------|------------------------------------------------------|-----------|
| Maximum Payload (including end-effector)                   | 25 kg (55 lb)                                        |           |
| Rated Payload (including end-effector)                     | 9 kg (19.8 lb)                                       |           |
| Reach                                                      |                                                      |           |
| Maximum radial                                             | 1066.8 mm (42.0 in.)                                 |           |
| Minimum radial                                             | 279.5 mm (11.0 in.)                                  |           |
| Vertical clearance (bottom of base to end-effector flange) |                                                      |           |
| - with maximum Joint 3 retraction                          | 876.3 mm (34.5 in.)                                  |           |
| - with maximum Joint 3 extension                           | 520.7 mm (20.5 in.)                                  |           |
| Vertical Stroke - Z direction                              |                                                      |           |
| Joint 3                                                    | 356 mm (14.0 in.)                                    |           |
| Joint Rotation                                             |                                                      |           |
| Joint 1                                                    | 300°                                                 |           |
| Joint 2                                                    | 300°                                                 |           |
| Joint 4                                                    | 540°                                                 |           |
| Inertia                                                    |                                                      |           |
| About Joint-4 axis - maximum <sup>a</sup>                  | 14,600 kg-cm <sup>2</sup> (5000 lb-in <sup>2</sup> ) |           |
| Force                                                      |                                                      |           |
| Joint 3 downward force without payload                     | 45 kg (100 lb)                                       |           |
| Cycle Time – 12 in. (305 mm) <sup>b</sup>                  | Burst                                                | Sustained |
| No payload                                                 | 0.62 sec                                             | 0.73 sec  |
| 9 kg (20 lb) payload (Rated)                               | 0.69 sec                                             | 0.89 sec  |
| 25 kg (55 lb) payload (Max)                                | 0.99 sec                                             | 1.24 sec  |
| Resolution                                                 |                                                      |           |
| Joint 1                                                    | 0.00078°                                             |           |
| Joint 2                                                    | 0.00078°                                             |           |
| Joint 3 (vertical Z)                                       | 0.0067 mm (0.00026 in.)                              |           |
| Joint 4 (tool rotation)                                    | 0.025°                                               |           |
| Repeatability                                              |                                                      |           |
| X,Y plane                                                  | ±0.038 mm (±0.0015 in.)                              |           |
| Joint 3 (vertical Z)                                       | ±0.038 mm (±0.0015 in.)                              |           |
| Joint 4 (rotational)                                       | ±0.05°                                               |           |

**Table 11-3. AdeptThree-XL Robot Performance Specifications (Continued)**

|                                         |                               |
|-----------------------------------------|-------------------------------|
| <b>Joint Speed (maximum)</b>            |                               |
| Joint 1                                 | 540°/sec                      |
| Joint 2                                 | 820°/sec                      |
| Joint 3                                 | 1000 mm/sec (39.4 in./sec)    |
| Joint 4                                 | 1955°/sec                     |
| <b>Weight</b>                           |                               |
| Robot without options                   | 266 kg (585 lb)               |
| Power chassis, with 3 amplifier modules | approximately 16.4 kg (36 lb) |
| Adept MV controller, with AWC and VGB   | approximately 14.5 kg (32 lb) |
| <b>Design Life</b>                      | 120 million production cycles |

<sup>a</sup> Maximum possible running at reduced speed.

<sup>b</sup> The robot tool performs a continuous-path motion consisting of all straight-line segments; 25 mm (1 in.) up, 305 mm (12 in.) over, 25 mm (1 in.) down, and returning along the same path. The endpoints of the cycle are approached in COARSE mode, with a brake at end-point.

**Table 11-4. AdeptThree-XL Robot Softstop and Hardstop Specs**

| Joint   | Default Softstop             | Hardstop (approximate)                              |
|---------|------------------------------|-----------------------------------------------------|
| Joint 1 | ±150°                        | ±152° (Braketrack) <sup>a</sup><br>±300° (Hardstop) |
| Joint 2 | ±150°                        | ±152°                                               |
| Joint 3 | 0 to 356 mm<br>(0 to 14 in.) | -6.6mm to 371 mm<br>(-.26 to 14.6-inch)             |
| Joint 4 | ±270°                        | None                                                |

<sup>a</sup> In between the softstop and hardstop, joint 1 has a braketrack. An internal proximity sensor will cause a V<sup>+</sup> error condition and shut down High Power to the robot if the braketrack area is entered.

## 11.5 Adept PA-4 Power Chassis Specifications

The following power consumption information is provided to allow customers to install adequate electrical wiring and power sources for worst case (short duration) demands of the Adept PA-4 power chassis. The typical values are for calculating air conditioning requirements.

**Table 11-5. Power Consumption for PA-4 Power Chassis**

| Line Voltage                               |               | Typical        | Worst Case    |
|--------------------------------------------|---------------|----------------|---------------|
| 380-415 VAC, 50/60Hz, 3 phase <sup>a</sup> | Current (RMS) | 8.5 amps/phase | 20 amps/phase |
|                                            | Watts         | 1.65 kW        | 3 kW          |
| 200-240 VAC, 50/60Hz, 3 phase              | Current (RMS) | 7.2 amps/phase | 17 amps/phase |
|                                            | Watts         | 1.65 kW        | 3 kW          |

<sup>a</sup> In the 380-415 VAC configuration, the Adept system draws current for a short duration during the positive peak voltage only.

### EMC Test Information

Information on EMC testing of the Adept control system can be obtained from the FAXBack numbers listed in “How Can I Get Help?” on page 41.

## 11.6 Harting Connectors

The following figure and tables provide the pin descriptions for the Harting connectors on the Arm Power cable.

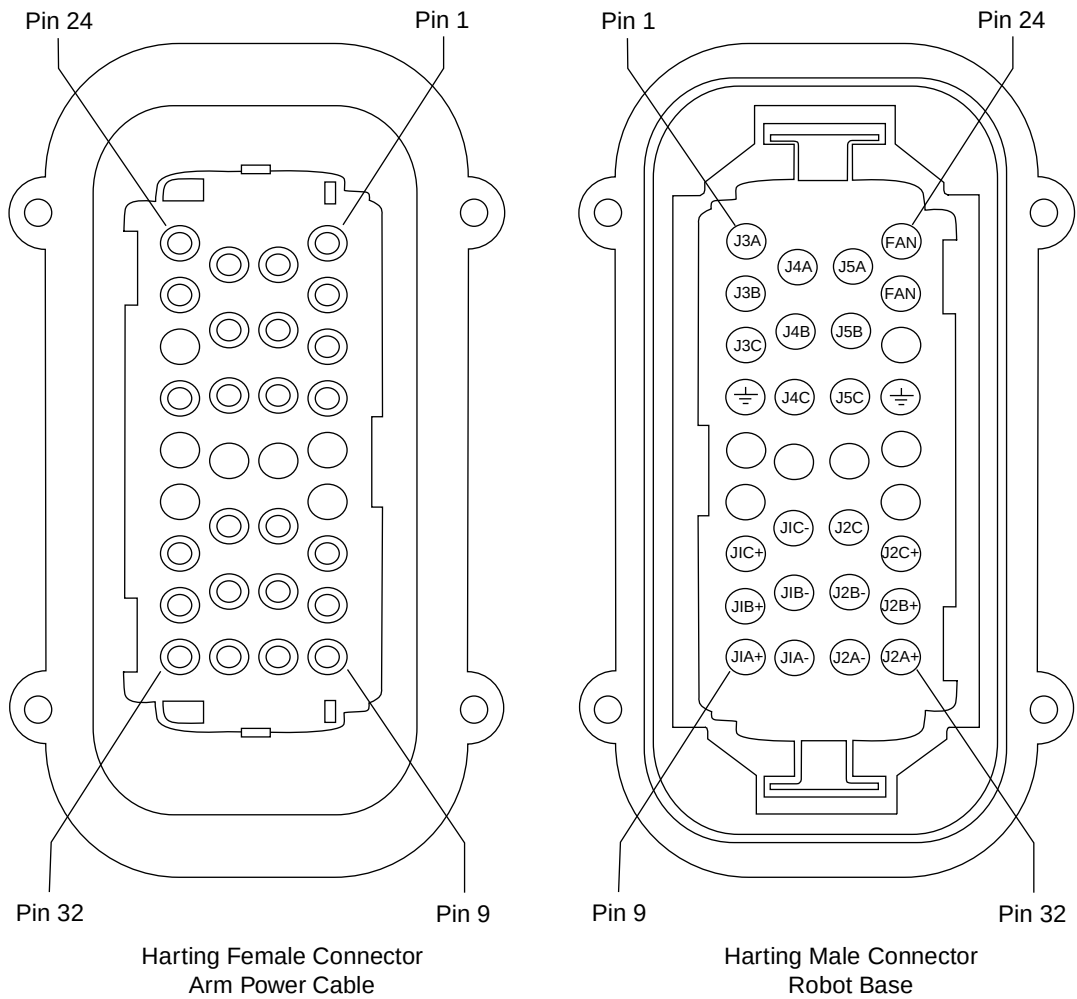


Figure 11-22. Harting Connector Pin Out

## Arm Power Connector Pin Identification

**Table 11-6. Arm Power Harling Connector Pin Identification**

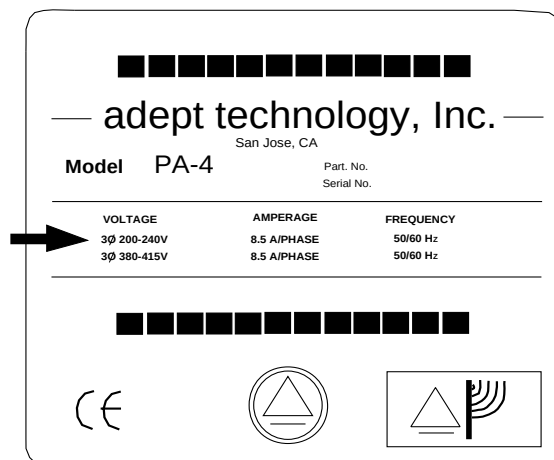
| Pin No. | Color   | Function       |
|---------|---------|----------------|
| 1       | BRN     | Jt 3 A         |
| 2       | ORG     | Jt 3 B         |
| 3       | BLU     | Jt 3 C         |
| 4       | GRN/YEL | Frame Ground   |
| 5       |         | Not used       |
| 6       |         | Not used       |
| 7       | ORG     | Jt 1 Outer C+  |
| 8       | RED     | Jt 1 Outer B+  |
| 9       | VIO     | Jt 1 Outer A+  |
| 10      | RED     | Jt 4 A         |
| 11      | VIO     | Jt 4 B         |
| 12      | YEL     | Jt 4 C         |
| 13      |         | Not used       |
| 14      | BLU     | Jt 1 Inner C–  |
| 15      | BLK     | Jt 1 Inner B–  |
| 16      | WHT     | Jt 1 Inner A–  |
| 17      | BRN     | Jt 5 A         |
| 18      | ORG     | Jt 5 B         |
| 19      | BLU     | Jt 5 C         |
| 20      |         | Not used       |
| 21      | BLU     | Jt 2 Inner C–  |
| 22      | BLK     | Jt 2 Inner B–  |
| 23      | WHT     | Jt 2 Inner A–  |
| 24      | BLK     | Fan            |
| 25      | BLK     | Fan            |
| 26      |         | Not used       |
| 27      | GRN/YEL | Frame Ground   |
| 28      |         | Not used       |
| 29      |         | Not used       |
| 30      | ORG     | Jt 2 Outer C + |
| 31      | RED     | Jt 2 Outer B + |
| 32      | VIO     | Jt 2 Outer A + |

Table 11-7. Motor Winding Resistance Check

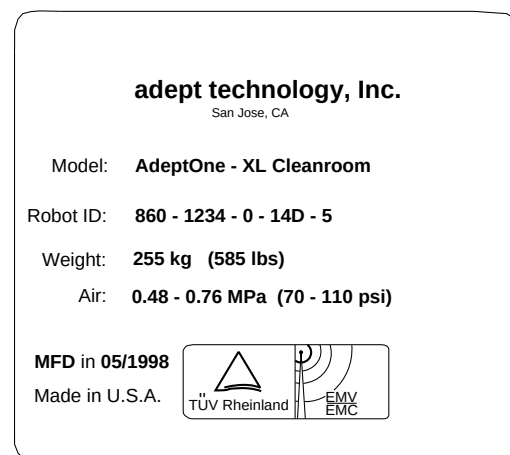
| Motor and Phase |             | Resistance Low Limit | Resistance High Limit |
|-----------------|-------------|----------------------|-----------------------|
| J1 Outer A+     | J1 Inner A- | 1.3                  | 1.7                   |
| J1 Outer B+     | J1 Inner B- | 1.3                  | 1.7                   |
| J1 Outer C+     | J1 Inner C- | 1.3                  | 1.7                   |
| J2 Outer A+     | J2 Inner A- | 1.4                  | 1.8                   |
| J2 Outer B+     | J2 Inner B- | 1.4                  | 1.8                   |
| J2 Outer C+     | J2 Inner C- | 1.4                  | 1.8                   |
| J3A             | J3B         | 4.4                  | 5.6                   |
| J3B             | J3C         | 4.4                  | 5.6                   |
| J3C             | J3A         | 4.4                  | 5.6                   |
| J4A             | J4B         | 4.4                  | 5.6                   |
| J4B             | J4C         | 4.4                  | 5.6                   |
| J4C             | J4A         | 4.4                  | 5.6                   |
| J5A             |             |                      |                       |
| J5B             |             |                      |                       |
| J5C             |             |                      |                       |

## 11.7 Robot ID Labels

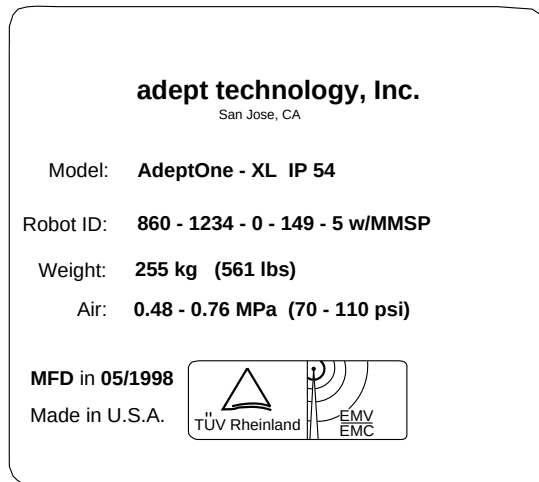
PA-4 ID Label



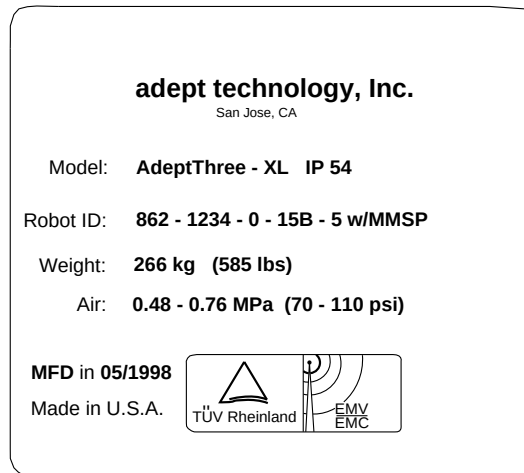
AdeptOne-XL Cleanroom ID Label



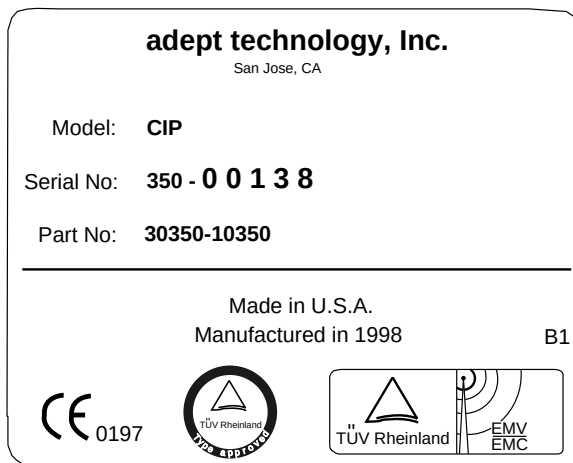
### AdeptOne-XL IP 54 ID Label (MMSP)



### AdeptThree-XL IP 54 ID Label (MMSP)



### CIP ID Label



# Adept-XL Robot Factory Installed Options

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## A.1 Adept-XL Cleanroom Option

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The Cleanroom Option can be ordered for all Adept-XL robots. This factory installed option allows the Adept-XL robot to meet Class 10 Cleanroom specifications.

This package includes the following:

1. Integral seals on the covers

**NOTE:** Seals are present under the access covers; see Figure A-1 on page 270. If removal of an access cover is necessary, the seal must be put back in place. The robot will **not** meet Class 10 Cleanroom specifications unless all seals are in place and proper vacuum is maintained.

2. A sealing plate under the base of the robot
3. A vacuum fitting (1-1/4 inch male thread)
4. Custom exterior paint finish

### Installation

The Cleanroom Option requires a customer-supplied vacuum system. This section details the vacuum requirements of the systems, installation procedures, and tests to assure that the system is maintaining adequate vacuum levels.

### Vacuum Requirements

Negative air pressure applied to the inside of the robot creates flow from the outside to inside through the gap between the inner and outer links. This type of system gives excellent cleanliness, but does not require high levels of vacuum.

The quill of the robot is covered by a Nitrile rubber bellows. The bottom of the bellows is clamped to a bearing so that the bellows flexes only in the Z (up and down) direction. The vacuum system maintains enough air velocity and pressure differential so that no particles escape. Because the volume contained by the bellows changes when joint 3 moves up and down, the system has been designed to accept this “pumped” air volume without allowing a positive pressure to develop across the bearing at the bottom of the quill or at the gap between the inner and outer links.

The seal between the inner and outer links allows air to flow freely from the outside of the robot toward the negative pressure inside the robot, pulling any particles into the arm.

Vacuum requirements are defined in terms of a required level of vacuum at the base of the robot and the flow required to create this level of vacuum. These requirements are listed below:

- Minimum input vacuum: 17 inches of water column (W.C.)
- Maximum input vacuum: 30 inches of water column (W.C.)
- Minimum air flow: 49 SCFM

A practical requirement is that a minimum vacuum be maintained at the quill, even during the fastest possible motions of joint 3. It is possible to adjust the amount of vacuum being applied to the system, provided the following minimum vacuum level is met when the robot is running at its fastest joint 3 motion.

- Minimum arm vacuum: 1.0 inch W.C. measured at the tool flange

These specifications result in sufficient vacuum to ensure that an installed, functioning robot will be clean, even at full speeds.

The plug covering the bottom of the tool flange has a 1/8 or 1/4 N.P.T. tapped hole. You can install a low pressure differential pressure meter at this point to measure the vacuum.

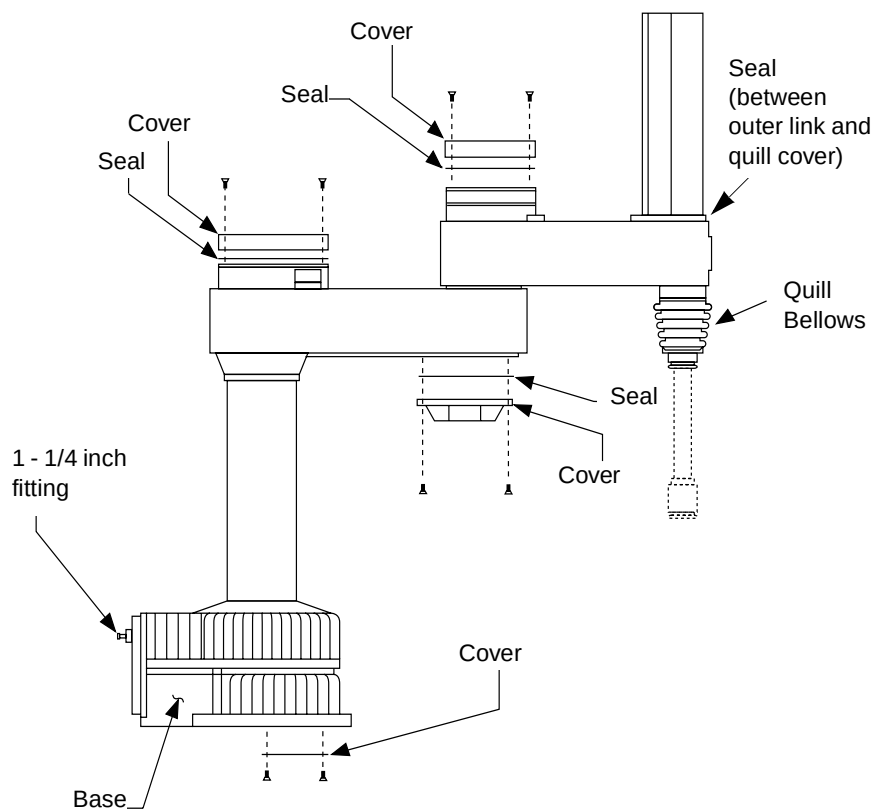


**Figure A-1. Adept-XL Cleanroom Features**

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## Vacuum Installation

### Vacuum Supply Pump

The vacuum supply pump must be sized based on the pipe size and the distance between the robot and vacuum pump.

### Pipe Size

The pipe sizes required when hooking up the robot to a vacuum source are a function of several factors:

- air flow requirements of the system
- distance from the vacuum pump to the robot
- vacuum pump used

Due to its low cost, ease of installation, good flow characteristics, and availability, most installations use PVC pipe. The following sections assume the use of PVC pipe.

The first consideration in pipe size is the location of the vacuum pump with respect to the robot. Given the location of the pump, a diagram displaying the pipe layout should be drawn. This allows the counting of fittings, and their conversion to equivalent pipe distances. Estimates of pipe fitting flows converted to straight pipe equivalents for three common pipe diameters are shown in Table A-1. These distances are then added to the nominal amount of straight pipe to create a total pipe length. There are practical limits to the length of pipe of a certain diameter.

The Adept-XL Cleanroom Robot Option provides a 1-1/4 inch male thread pipe fitting for the vacuum connection on the outside of the base of the robot, see Figure A-1 on page 270. This can be adapted to any vacuum supply pipe being used. Adept recommends the connection include the following features:

- A union at the robot that allows the robot to be removed from the workcell.
- A tee with a threaded plug machined to accept a vacuum-sensing switch. This allows the vacuum to be tested.
- A gate valve in line with the vacuum piping and located near the robot. This will allow regulation of the vacuum at the robot. Keep in mind that gate valves have flow losses 10 to 12 percent higher than that of globe or ball valves.
- A union at the wall separating the vacuum pump and robot.
- A union at the vacuum pump that allows the pump to be replaced.

**Table A-1. Pipe Fitting Flow Equivalents (in Feet of Straight Pipe)**

| Fitting   | Pipe Size    |              |          |
|-----------|--------------|--------------|----------|
|           | 1-1/4 inches | 1-1/2 inches | 2 inches |
| 90 degree | 7 feet       | 8 feet       | 10 feet  |
| 45 degree | 1.5 feet     | 1.8 feet     | 2.3 feet |

## Vacuum Switch

Maintaining adequate levels of vacuum is critical for cleanroom environments. The robot gives no external indication whether the vacuum is present or not. Adept suggests vacuum switches be used as a method of assuring proper vacuum is present.

Such a switch could provide contact closure while the vacuum is within the appropriate range. The switch can be used in series with any other external E-Stop devices. This method will allow High Power to be turned on only if vacuum is present. The user would see an \*External E-Stop\* error message on the system monitor/terminal, if the vacuum fails.

**NOTE:** To comply with the requirement for redundant E-Stop loops, use two independent switches if an E-Stop is needed to sense the presence of proper vacuum.

## Testing the Vacuum

Setting the vacuum switch requires that all parts of the robot and vacuum systems be installed. High Power need not be enabled, but the sealed Arm Power and Arm Signal cables connecting the robot to the Adept MV controller and Adept PA-4 power chassis must be connected. Connect a vacuum gauge to the pipe tee just outside the robot's vacuum supply fitting. Turn the vacuum system on and wait a few moments for the system to stabilize. Adjust the vacuum to within the limits mentioned in "Vacuum Requirements" on page 269, plus roughly 1-1/2 inches W.C. of vacuum. Adjust the switch so that this is the vacuum falling setpoint. That is, set the switch for this point, apply more vacuum, then gradually reduce the amount of vacuum until the switch trips. This helps compensate for switch hysteresis. The extra 1-1/2 inches of vacuum allows for the normal swing of vacuum (roughly 1 inch) as joint 3 is moved up and down. Reset the vacuum supply to the normal setting.



**CAUTION:** The vacuum supply to the Adept-XL Cleanroom robot must be on 24 hours per day to maintain the Class 10 Cleanroom rating. Failure to supply vacuum to the robot 24 hours per day can void the warranty and contaminate the cleanroom environment.

---

## A.2 Adept-XL Robot IP 54 Option

IP 54 means “dust protected and protection against water splashing”.

- Dust Resistance - protection of the equipment inside the robot shell against ingress of solid foreign objects
- Specifically for IP 54 Dust Protection - “Ingress of dust is not totally prevented, but dust shall not penetrate in a quantity to interfere with the satisfactory operation of the robot or impair safety”
- Water Resistance - protection of the equipment inside the robot shell against harmful effects due to the ingress of water
- Specifically for IP 54 Water Protection - “Water splashed against the robot enclosure from ANY direction shall have no harmful effects”

The factory installed IP 54 option kit provides an improved level of dust and water protection (dust-tight and protection against water splashing).

The Adept-XL robot product line, with the IP 54 option, includes the following upgrades:

- Corrosion-resistant external fasteners
- Joint 1 drive tube sealing hardware
- Joint 2 labyrinth sealing design
- Gasketed access covers for the quill, Joint 2 encoder, and inner and outer link covers
- Blower attachment fitting/sealing arrangement at the robot’s base
- Stainless steel tool flange

When configured with the IP 54 Option, the Adept-XL robot product line meets the dust and water protection requirements, as defined in IEC 529, “Degrees of protection provided by enclosures (IP Code)”.

### IP 54 Adept-XL Robot

The standard Adept-XL robot, which has an IP 20 rating, can be upgraded to an IP 54 protection class with the IP 54 hardware upgrade kit (see Table A-2 on page 274). To achieve the IP 54 rating, the kit provides custom gaskets for the quill cover, joint 1 upper cover, joint 2 upper cover, and joint 2 lower cover, a multipurpose joint 1 drive tube dynamic seal and deflector, blower attachment fitting, lower base baffle plate, and corrosion-resistant fasteners.

All gaskets and seals are made from Nitrile rubber, which provide excellent sealing capabilities and wear resistance.



**CAUTION:** Damage or removal of any one of these upgrades can lead to reduction in IP protection level, damage to the robot system, or damage to customer hardware.

Gaskets and seals should be inspected periodically and replaced immediately after finding damage.

**Table A-2. IP 54 Hardware Upgrade Kit**

| Nomenclature                                                               | Adept Part Number |
|----------------------------------------------------------------------------|-------------------|
| Gasket Kit (Joint 1 Upper, Joint 2 Upper, Joint 2 Lower, and Quill Covers) | 90862-00800       |
| Joint 1 Drive Tube Seal                                                    | 40862-10660       |
| Gasket Adhesive                                                            | 87333-00404       |
| O-ring Grease                                                              | 85304-00000       |
| Baffle and Blower Plate Gasket                                             | 40862-10650       |
| Blower Fitting Gasket                                                      | 40862-10430       |

## Customer Requirements

While the IP 54 hardware upgrade kit provides most of the hardware needed to achieve an IP 54 protection level, customers must provide a way of sealing the tool flange and pressurizing the robot through the blower attachment fitting (located at the base of the Adept-XL robot). These two requirements, sealing the tool flange and pressurizing the robot, are critical to achieving the IP 54 level of protection.

### Sealing the Tool Flange

The tool flange must be sealed so that the robot shell can be positively pressured. The positive pressure reinforces the sealing properties of the gaskets and seals provided in the IP 54 kit. Joint 2 has no seal or gasket and achieves IP 54 protection levels through positive pressure alone. This fact is critical when selecting a blower to pressure the robot.

### Pressurizing of the Robot

The robot is pressurized through the blower attachment fitting located at the base of the robot (see Figure A-1 on page 270). The fitting provides for attachment of a 3-inch diameter hose secured with a 1/2-inch wide hose clamp.

Blower requirements should be based on Z-stroke and payload of the user's application. In general, long Z-strokes with small payloads require more pressurization, while short Z-strokes with large payloads require less pressurization (because the bellows acts as a pump actuated by joint 3 motion). A graph of pressure and flow requirements based on Z-stroke and payload is shown in Figure A-2 on page 275. These pressure and flow requirements are at the blower attachment fitting.

The blower must supply clean, dry air. Blowing moist dirty air into the robot may reduce the life of the robot or cause internal damage.

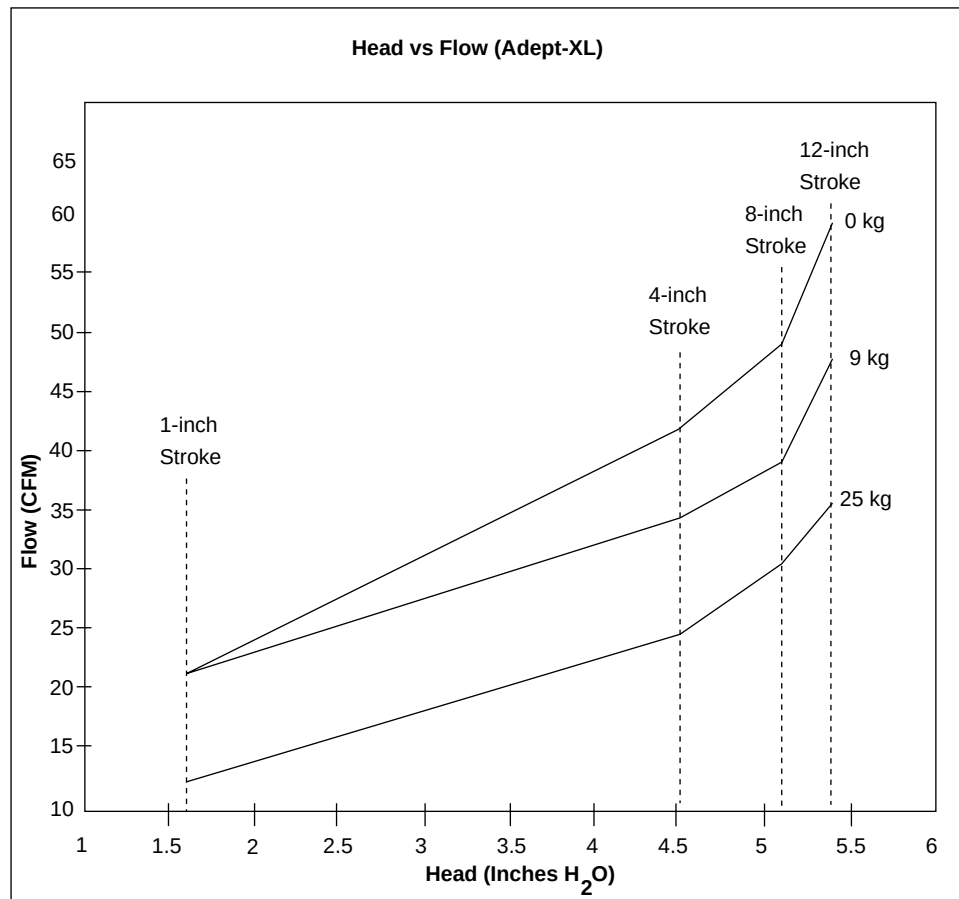


**Figure A-2. Z-Stroke and Payload**



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# Adept User's Manual Comment Form

We have provided this form to allow you to make comments about this manual, to point out any mistakes you may find, or to offer suggestions about information you want to see added to the manual. We review and revise user's manuals on a regular basis, and any comments or feedback you send us will be given serious consideration. Thank you for your input.

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Technical Publications Dept.  
150 Rose Orchard Way  
San Jose, CA 95134

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